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Published in:
Frontiers in Education

DOI:
10.3389/feduc.2020.586122

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2020

frontiers in Education

ORIGINAL RESEARCH
published: 10 December 2020
doi: 10.3389/feduc.2020.586122

Monitoring Communication Development Between Teachers and Their Students With Congenital Deafblindness: An Application of the Layered Communication Model

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Specialty section:
This article was submitted to Educational Psychology, a section of the journal Frontiers in Education

Received: *22 July 2020*
Accepted: *04 November 2020*
Published: *10 December 2020*

Citation:
Wolthuis K, Bol GW, Minnaert A and Janssen MJ (2020) Monitoring Communication Development Between Teachers and Their Students With Congenital Deafblindness: An Application of the Layered Communication Model. Front. Educ. 5:586122. doi: 10.3389/feduc.2020.586122

The Layered Communication Model (LCM) consists of three layers of intersubjective development divided into different communicative behaviors per layer. Earlier research showed that the LCM can be used to describe the communication level between teachers and their students with congenital deafblindness (CDB). This study analyzed whether the LCM can also be used to monitor the development of LCM behaviors over time. Videos of eight student-teacher dyads recorded at the start of this study (baseline phase) and 5 months later (follow-up phase) were coded using 10-s partial interval coding. The presence of the communicative behaviors at the three layers of the LCM during baseline and follow-up were calculated and compared between dyads and phases. The results on the presence of LCM behaviors were in line with earlier research. The presence of primary layer behaviors was comparable between dyads, confirming that this is a basic communication layer. The differences found between dyads in the presence of secondary and tertiary layer behaviors shows that these can be used to determine a dyad's communicative level. Results also showed that the LCM can be used to monitor communication development. Small increases were found in the presence of LCM behaviors between baseline and follow-up for the primary layer behaviors, but larger increases were found for secondary and tertiary layer behaviors, showing that development can be monitored. In conclusion, this study again showed that the LCM can be used to *describe* a dyad's communicative level. We also found increases in the presence of certain behaviors between baseline and follow-up for all dyads, which shows that the LCM can also be used to *monitor* communication over time. More insight into the period between the analyzed phases is suggested to analyze what might have caused the increase in presence of behaviors. This would reveal more about the use of the LCM as a tool to *improve* communication development.

Keywords: deafblind communication, student-teacher interaction, video observation method, partial interval coding, communication development, intersubjectivity, layered communication model, congenital deafblindness

INTRODUCTION

Students with deafblindness form a very heterogeneous population of children with varying degrees of hearing and vision impairments (Dalby et al., 2009). According to Dammeyer (2010), given the Nordic definition, deafblindness is a combined vision and hearing disability that limits a person's activities and restricts their full participation in society to such a degree that society is required to facilitate specific services, environmental alterations, and/or technology. The combination of impairments in both hearing and seeing results in a condition with more impact on development than a simple sum of both (Dammeyer, 2014).

The UNESCO report on special needs education states that student development should be monitored and documented (UNESCO, 1994). This is difficult for students with CDB in all areas of education, including communication and language development. For most students with CDB, communication development occurs at a very slow pace, which is often only recognized by the teachers who work closest with the student. Monitoring tools used in education (even those from special needs education) are often not sensitive enough to detect the slow communication development of children with CDB. Also, teachers need to know their students' communication level to be able to set appropriate goals for improvement, or to support their students in making transitions from a school situation to a work or care situation. There is a need for a model that can describe, monitor and improve communication of people with congenital deafblindness.

For this purpose, Wolthuis et al. (2019) introduced a Layered Communication Model (LCM) that is based on a description of communicative behaviors in three consecutive layers of early development (see **Table 1**). In their explorative study, video recordings of four student-teacher dyads were analyzed to describe their communication level and monitor development. The found developmental character of the LCM suggested that this model can be used as a tool to describe a dyad's communicative level. Change over time was, however, not found, therewith failing to show LCM's use as a tool to monitor communication development. The exploratory nature of the study required more research to confirm its findings (Barlow et al., 2009).

Therefore, the current study aims at further analyzing the use of the LCM as a tool to describe communication and as a tool to monitor communication development for students with CDB.

The Layered Communication Model

The LCM as described by Wolthuis et al. (2019) is based on Bråten and Trevarthen's theory on intersubjective communication development, which emphasizes the interpersonal aspect of communication that starts from birth and which focuses less on linguistic milestones that are often hard for children with CDB to achieve (Bråten and Trevarthen, 2007).

The build-up of the three layers is based on the way the dyad interacts with their surroundings. In the first layer, the participants within the dyad have a strong focus on the other only. In the secondary layer, the dyad can share interest in objects and other people that are directly present. In the tertiary layer, the dyad is capable of communicating about absent objects and people and they can take each other's perspective (**Figure 1**).

An in-depth description of the creation of the LCM model is beyond the scope of this article. Hence, we refer to the study of Wolthuis et al. (2019) for more theoretical underpinnings of the model. **Table 1** summarizes descriptions and definitions of the different communicative behaviors belonging to the three layers of intersubjective development.

Describing the Communication Level of a Dyad Using the LCM

The LCM is based on research on typically developing children. Wolthuis et al. (2019) explored the applicability of the LCM to describe the communication level of people with CDB communicating with their teachers by analyzing video recordings of four student-teacher dyads from which the students had varying developmental ages. A coding schema was created based on the LCM, with which the presence of the different behaviors could be observed in video recordings for 10-s intervals. Wolthuis et al. (2019) concluded that the developmental character of LCM was reflected by the quantitative differences found in the presence of the LCM behaviors both *between dyads* as well as *between and within layers* of the model.

Primary layer behaviors were found in comparable quantities for all four dyads, which is similar to earlier research that suggested that this is a basic communication layer (Janssen et al., 2003; Damen et al., 2015; Bloeming-Wolbrink et al., 2018). However, at the secondary and tertiary layer, differences between dyads were found. Secondary and tertiary layer behaviors were more often present for students with higher developmental ages than those with lower developmental ages, which showed the developmental character of the LCM.

The second indicator for the developmental character of the model was found in the quantitative differences in presence of the behaviors *between and within the three layers*. For all dyads, primary layer behaviors were found more often than behaviors at the secondary layer, and tertiary layer behaviors were found least often for all dyads. Differences in the presence of behaviors were also found within layers. At the primary layer, these differences appeared to be unrelated to the developmental age of the student. *Affective involvement* and *imitation* were present less often than *shared attention* and *turn-taking*, but this was explained by the momentous vs. continuous nature of these behaviors during communication (Wolthuis et al., 2019). At the secondary and tertiary layer, quantitative differences between behaviors appeared to be more related to the developmental age of the student. *Naming objects* was always found less often than *joint attention* (at the secondary layer), whereas *perspective taking* was always found less often than *symbolic communication* (at the tertiary layer). The quantitative differences between these behaviors indicated a hierarchical order within these two layers, which can also be found in typically developing children (Carpenter et al., 1998).

TABLE 1 | The Layered Communication Model: characteristic communicative behaviors for each layer of intersubjective communication development.

Layer of development	Average age in typical development	Characteristic behaviors	Description
Primary layer	0–9 months	(Neonatal) imitation	Imitating other people's facial expressions and other movements
		Mutual attention	Sharing attention to each other or to the shared activity
		Affective involvement	Sharing positive and negative emotions
		Turn-taking	Alternating turns in interactions like songs and games
Secondary layer	9–18 months	Joint attention	Focusing on an object or sharing it with others outside the dyadic child-parent interaction
		Naming objects	Using and understanding symbols for objects or people that are directly present
Tertiary layer	From 18 months	Symbolic communication	Making and understanding conversations about absent things and people
			Talking about future and past events
			Talking about wishes and desires
	From 3–4 to 6 years	Perspective taking	Discovering deceit (lying and joking)
			Attributing false beliefs to others
			Understanding others' minds and emotions
			Exhibiting prosocial behavior
			Roleplaying

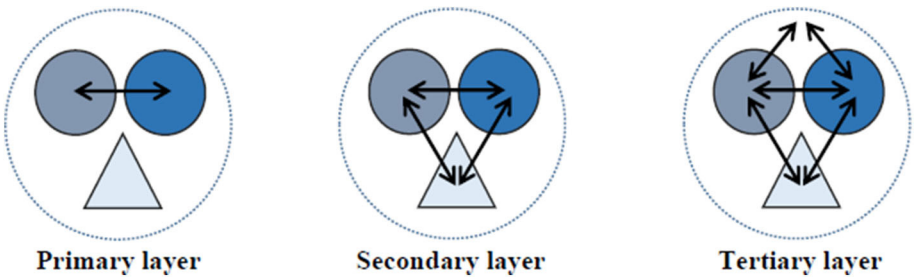

FIGURE 1 | Graphic display of the three layers of intersubjective communication development: Primary layer: interactions between child and caregiver; Secondary layer: interactions between child, caregiver, and objects; Tertiary layer: interactions between child, caregiver and their surroundings.

Monitoring Communication Development Using the LCM

In order to monitor communication development, a monitoring tool (such as the LCM) can be used at several moments in time to analyze change. Given the developmental aspect of the LCM, it is expected that such change will show in an increase in presence of behaviors over time.

Wolthuis et al. (2019) used their coding schema to measure the presence of LCM behaviors at different moments during a half-year period (with no specific intervention involved). No pattern of increase in the presence of LCM behaviors was found in this study. The authors discussed whether this was caused by an absence of development, or because only one recording was analyzed per phase, which could have been unrepresentative for the dyads' potential (cf. Damen, 2015). However, it remained unclear whether the LCM could be used to monitor development over time.

Aim of the Study

The aim of the current study is to find out whether the LCM can be used not only to describe a dyad's communicative level, but also as a tool to monitor communication development over time.

The current study is partially replicative and partially ads new methods. The use of the LCM as a tool to describe communication is re-analyzed with eight instead of four dyads. The use of the LCM as a tool to monitor communication development is analyzed in a different way compared to the former study (Wolthuis et al., 2019). Instead of analyzing one video recording every 6 weeks for a period of 5 months, we analyze three to four videos recorded at the start of the study (baseline) and compare these to three to four videos recorded 5 months later (follow-up). The presence of the LCM behaviors during baseline and follow-up recordings is described and compared for eight dyads with students with varying developmental ages.

Concerning the use of the LCM to describe communication, we expect our results to be comparable to those in the study of

Wolthuis et al. (2019). This means that quantitative differences between behaviors (lower for affective involvement and imitation vs. higher for shared attention and turn-taking) at the primary layer, but not between the different dyads can be expected. This would further confirm that the primary layer serves as a basis for communication development (Janssen et al., 2003). Also, the developmental aspect of the LCM is expected to be reflected in the results of the presence of secondary and tertiary layer behaviors, in such a way that secondary layer behaviors will be found more frequently than tertiary layer behaviors. Furthermore, we expect the presence of behaviors from these two layers to be related to the developmental ages of the students, meaning that all behaviors will be more often present for students with higher developmental ages and less often for students with lower developmental ages.

Concerning the use of the LCM to monitor communication development, we expect to find increases in presence of LCM behaviors between baseline and follow-up recordings. Analyzing multiple recordings per phase is expected to provide a better representation of the dyads' potential than the analysis of one single recording per phase. Based on the assumption that the primary layer serves as a basic communication layer, we expect that the presence of primary layer behaviors will increase between phases for dyads where secondary and tertiary layer behaviors are infrequently present or absent at the baseline. In contrast, once secondary and tertiary layer behaviors are present for a dyad at the baseline, we expect little improvement in primary layer behaviors. In other words, the degree of improvement between phases depends on the dyad's communicative level during baseline recordings.

This study analyzes the presence of LCM behaviors at the three layers of intersubjective development for eight different student-teacher dyads and analyzes how the presence of these behaviors changes over time.

METHODS

We analyzed communication between eight teacher-student dyads by coding videos that were recorded in the 4 weeks before and 4 weeks after an intervention was conducted. This study uses a baseline logic, so participants served as their own control for evaluating change (Gast and Hammond, 2010). Results are described for each dyad separately, followed by a group analysis to analyze and describe differences between the students' developmental ages (Barlow et al., 2009; Gast and Hammond, 2010).

Participants

This study was approved by the ethical committee for Pedagogical and Educational Sciences at the University of Groningen, the Netherlands. Eight students with CDB and their teachers from a Dutch school for children with deafblindness participated. The teachers and the students' parents or legal representatives gave written consent to participate in this study.

Student and Teacher Characteristics

The degree of hearing and vision loss differs between people with CDB, which is also the case for the eight students in this study. Three students are completely blind with hearing loss and the other students all have residual hearing and vision to varying degrees (see **Table 2**). Developmental ages varied between students in order to analyze the developmental character of the LCM.

Dutch schools for children with CDB use the following criteria for their students. They have both a hearing and vision impairment, in which the hearing loss is 35 decibels or more in the better ear when not wearing hearing aids or a cochlear implant. They have vision impairment with a visual acuity of 30% or less, or a purview of 30° or less. Students are also admitted to the school if they have a syndrome or neurological impairment that causes sensory processing issues to such a degree that the student functions as a person with deafblindness. In those cases, the student needs to have the potential to develop a form of communication (Kentalis, 2017).

The students' ages ranged from 4 to 18 years at the time of the recordings, and their school files showed estimated developmental ages of between 8 months and 14 years. These developmental ages are estimates, as no diagnostic tests exist specifically for children with CDB. The participating school uses adaptations of diagnostic tests such as the Snijders-Omen non-verbal intelligence test (SON-R) (Tellegen and Laros, 2011), the Dutch version of the Bayles Scales of Infant Development-II (BSID-II) (Ruiter et al., 2003), and the Southern Californian Ordinal Scales of Development (SCOSD) (Ashurst et al., 1985). The use of different tests and scales can sometimes cause a range in estimated developmental ages of the students, as can be seen in **Table 2**. The layer of intersubjective development is estimated based on the students' developmental ages, combined with information from school files and analysis from the school's educational psychologist. On average, the teachers had more than 20 years of experience working with children with CDB.

Data Gathering

Video Recordings

Weekly videos of the dyads communicating in a one-on-one situation in their classroom were recorded by the first author and four volunteers with a regular handheld camera with or without a tripod (depending on the activity). The recorders were instructed to stay in the background in the classroom and record the full bodies of both the student and teacher. Teachers were asked to choose the moment in their weekly schedule that was most dedicated to communication and interaction. The chosen activity varied between dyads, from singing songs and playing musical instruments or doing hands and craft, to planning and discussing a day or week (see **Table 2**). Within dyads, the activity was the same in all recordings. Recordings were intended to last 20–30 min, but they were sometimes shorter due to a lack of concentration by the student or other unexpected circumstances.

Four videos per dyad were recorded before the intervention started (baseline phase) and four videos were recorded after the intervention ended (follow-up phase). Due to illness or absence of the student or teacher, one baseline recording is missing for

TABLE 2 | Characteristics of the participating dyads.

	Dyad 1	Dyad 2	Dyad 3	Dyad 4	Dyad 5	Dyad 6	Dyad 7	Dyad 8
Estimated developmental age of the student[a]	8 months	8 months	12–18 months	18–24 months	18–24 months	12–25 months	5 years	8–14 years
Estimated layer of intersubjectivity[b]	1	1–2	1–2	1–2	2–3	2–3	3	3
Hearing impairment[c]	Severe hearing impairment in one ear, moderate in other ear. Wears cochlear implants in both ears occasionally	Slight hearing impairment when wearing hearing aids	Slight hearing impairment in both ears, wears no hearing aids	Profoundly deaf in both ears, wears no hearing aids	Slight hearing impairment in both ears, no hearing aid	Slight hearing impairment when wearing hearing aids	Moderate hearing impairment in one ear, slight in other when wearing hearing aids	Moderate hearing impairment in one ear, profoundly deaf in other ear
Visual impairment[d]	Blind in both eyes	Mild visual impairment for both eyes	Blind in both eyes	Blind in one eye, low vision in other eye	Blind in both eyes	Blind in one eye, low vision in other eye	Blind in one eye, low vision in other	Mild visual impairment
Description of communicative situation	Singing songs and exploring toys and guitar	Singing songs and exploring toys	Welcoming at school, singing songs	Welcoming unpacking backpack, eating in pantry	Planning the afternoon activities and working on hands and crafts	Word learning activities and games	Communicating about weekend activities with the use of (enlarged) photos	Communicating about one topic chosen by student and one chosen by teacher

[a] *Based on test results of the SON-R (Tellegen and Laros, 2011), the Dutch version of the BSID-II (Ruiter et al., 2003), and the SCOSD (Ashurst et al., 1985). Since these tests are not specially developed for children with congenital deafblindness, the developmental ages of our participants are estimates.*

[b] *Based on school files and the students' educational psychologist.*

[c] *Slight hearing impairment: 26–40 dBHL, Moderate hearing impairment: 41–60 dBHL, Severe hearing impairment, 61–80 dBHL, Profound hearing impairment/deafness: 81 dBHL and greater (World Health Organization, 2001).*

[d] *Normal vision: visual acuity 1.0–0.8, Mild visual impairment: 0.63–0.32, Low vision-blindness: 0.3–0.0 (World Health Organization, 2003).*

dyads 2 and 7, and one follow-up recording is missing for dyads 3, 4, 6, and 7. The time between the first baseline recording and the last follow-up recording is ∼5 months.

Cutting Video Recordings

The duration of the video recordings varied from 10 to 45 min. Depending on the length of the shortest recording per dyad, recordings were cut into fragments of either 10 or 15 min. Each recording was cut in the same manner for each dyad. The first and last 5 min mostly showed a start and ending of the activity, which is often accompanied by communicative rituals. Therefore, each recording was cut into fragments of 5 min from the start of the recording, 5 min from the end and 5 min from the middle of the recording. The first fragment starts at the moment when the teacher and student are both in sight and/or the activity starts. The last fragment consists of the last 5 min before the moment when the student or teacher is out of frame, or when the lesson is clearly ended by one of them. Five minutes around the exact middle of the remaining minutes of the recording is the third fragment coded in this study. For the dyads for which recordings of 10 min were the maximum length, we used the same method; however, we cut 3-min fragments at the beginning and end and 4 min from the remainder of the recording.

Coding Video Recordings

The cut fragments were coded with a scheme using partial interval coding (MacLaren Chorney et al., 2014). To enable us to compare the results with those from the study by Wolthuis et al. (2019), we used a 10-s interval coding in this study as well. For each LCM behavior, we coded whether a behavior was present or absent during these intervals. Since behaviors of people with CDB can be very complex, subtle, and idiosyncratic, Prain et al. (2012) recommend measuring interobserver reliability by calculating both percentage agreement and Cohen's Kappa (Cohen, 1960). Therefore, 25% of the recordings of each dyad were coded by two coders. Recordings per dyad were renamed and randomized in such a way that none of the coders knew which recording belonged to the baseline or follow-up recordings.

Agreement between coders is considered to be sufficient when percentage agreement exceeds 80% and Kappa is higher than 0.60 (Prain et al., 2012). In this study, Kappa scores varied between 0.73 and 0.92 and percentage agreement varied from 87 to 93% between coders.

Intervention Between Phases

After recording the baseline videos, an intervention was conducted. Since this study focuses on the change in presence of LCM behaviors between baseline and follow-up, the content of the intervention will only be briefly explained here. The intervention consisted of two phases, of which the first phase was a self-assessment of the teachers' ability to improve communication. This helped teachers to evaluate their own performance and to observe and interpret their behavior in order to improve outcomes (Klenowski, 1995; Ross, 2006). The second phase consisted of two video-feedback coaching sessions, which has proven to be an effective method for coaching teachers and changing behavior (Fukkink and Trienekens, 2011).

Data Analysis

The codes obtained from the partial interval coding were used to describe the presence of the LCM behaviors during baseline and follow-up for each dyad. Dyads were ordered based on the students' estimated developmental ages, from lowest to highest. The presence of each behavior was calculated as a percentage of the total intervals coded per dyad and each LCM behavior's presence was described and analyzed for deviant percentages between recordings.

To describe the increase in LCM behaviors between baseline and follow-up, we calculated the difference in the behaviors' presence between phases. Results show the increase or decrease in presence of the behaviors between the average of the baseline recordings and those of the follow-up.

Finally, we made a group analysis to find out more about differences and similarities between dyads. That analysis presents the presence of the LCM behaviors for the combined recordings at baseline and follow-up and compares them between dyads. This offers insights into the differences in developmental ages of the students with CDB. Furthermore, the differences in presence between the two phases were compared between dyads.

RESULTS

Results are presented for each dyad separately, in order of the students' developmental ages. This is followed by a group analysis.

Dyad 1

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Four videos were recorded during baseline and follow-up. *Symbolic communication* and *perspective taking* were not present for this dyad.

At the primary layer, the presence of *affective involvement* was low in both phases, with a complete absence in two of the baseline recordings and a maximum of 12.2% in the last follow-up recording The presence of *imitation* varied between recordings in both phases (between 5.5 and 42.2%). At the baseline, the presence of this behavior was relatively low in the third recording (5.6% vs. around 25%). During follow-up, the first recording showed a relatively high presence of *imitation* (42.2%), while the presence in the other follow-up recordings varied around 10%. *Mutual attention* and *turn-taking* frequently were present in all recordings (around 80%). However, the third baseline recordings showed a little lower percentage for *mutual attention* than the other baseline recordings (68.9%) and, during follow-up, the presence of *mutual attention* was more than 10% higher in the first recording than in the other recordings of this phase. *Turn-taking* was also present 10% more often in the first follow-up recording.

At the secondary layer, the presence of both behaviors was around 20% in the baseline recordings and around 35% in the follow-up recordings. *Joint attention* was relatively infrequently present in the fourth baseline recording (7.8%) compared to the other recordings in this phase, and *naming objects* was relatively infrequently present in the third baseline recording (8.9%). The presence of both behaviors was stable during follow-up recordings (see **Table 3**).

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

At the primary layer, there were small differences between phases (see the last column of **Table 3**, where a positive number indicates an increase and a negative number indicates a decrease between phases). Three of the four behaviors were more often present during follow-up than in the baseline recordings, but this increase was just around 1%. The presence of *imitation* decreased with 2%.

Large differences between phases were found at the secondary layer of the LCM. The presence of both behaviors increased between phases, by almost 8% for *naming objects* and more than 15% for *joint attention*.

Dyad 2

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Three videos were recorded during baseline and four during follow-up for this dyad. Symbolic communication and perspective taking were absent during recordings.

The presence of *affective involvement* and *imitation* fluctuated around 15% in most baseline recordings and was close to 30% in most follow-up recordings (see **Table 4**). Two recordings in each phase show divergent percentages. The presence of *affective involvement* was over 30% higher in the second baseline recording and 20% higher in the third follow-up recording than in the other recordings for these phases. The presence of *imitation* was relatively high in the first baseline recording (28.9%) and relatively low in the first follow-up recording (17.8%). The presence of *mutual attention* and *turn-taking* was just under 100% in all the recordings in both phases.

At the secondary layer, the difference in percentage of presence between the two behaviors was large. The presence of *joint attention* was around 50% or more, while naming objects was present in around 15–25% per recording. *Naming objects* had stable percentages for the recordings per phase, while the presence of *joint attention* was relatively low in the first follow-up recording (17.8%).

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

Although most increases were small, the presence of all the primary layer behaviors increased between baseline and follow-up recordings (see final column of **Table 4**). The only large increase at this layer was for *imitation*, which was 12% more often present during follow-up than in the baseline recordings. At the secondary layer, an opposite pattern can be found between behaviors. The presence of *joint attention* decreased greatly, by more than 10%, while *naming objects* increased by almost 5%.

TABLE 3 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 1.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	7.8	0	0	11.1	4.7	6.7	2.2	3.3	12.2	6.1	1.4
Imitation	27.8	24.4	5.6	25.6	20.9	42.2	6.7	14.4	12.2	18.9	−2
Mutual attention	78.9	87.8	68.9	90	81.4	91.1	80	78.9	80	82.5	1.1
Turn-taking	75.6	86.7	68.9	90	80.3	90	78.9	78.9	80	82	1.7
Secondary layer											
Joint attention	33.3	28.9	23.3	7.8	23.3	44.4	35.6	42.2	32.2	38.6	15.3
Naming objects	23.3	36.7	8.9	22.2	22.8	31.1	24.4	33.3	33.3	30.5	7.7

TABLE 4 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 2.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	17.8	52.2	15.6	-	28.5	28.9	15.6	53.3	28.9	31.7	3.2
Imitation	28.9	13.3	5.6	-	15.9	17.8	31.1	32.2	30	27.8	11.9
Mutual attention	98.9	100	98.9	-	99.3	100	100	100	100	100	0.7
Turn-taking	96.7	100	100	-	98.9	100	100	100	100	100	1.1
Secondary layer											
Joint attention	48.9	63.3	71.1	-	61.1	17.8	67.8	46.7	68.9	50.3	−10.8
Naming objects	15.6	18.9	17.8	-	17.4	20	20	22.2	25.6	21.9	4.5

Dyad 3

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Four videos were recorded during baseline and three during follow-up. *Symbolic communication* and *perspective taking* were absent in the recordings of this dyad.

The behaviors *affective involvement* and *imitation* were infrequently present in both phases for this dyad (see **Table 5**). The presence of *affective involvement* was lower than 10% in all baseline recordings. The high presence of this behavior in the second follow-up recording (26.7%) differs from the other two follow-up recordings. The presence of *mutual attention* and *turn-taking* was over 90% in almost all baseline and follow-up recordings. The only exception is the third baseline recording, in which both behaviors were 10% less often present than in the other recordings of this phase.

At the secondary layer, the presence of both behaviors varied a little more. The presence of *joint attention* was between 30 and 40% in most baseline recordings and around 30% in the follow-up recordings. Both phases include one deviant recording in which *joint attention* was less often present; in the second baseline recording and the first follow-up recording, the behavior's presence was only 10%. The presence of *naming objects* varied around 30% in most baseline and follow-up recordings. In the first baseline recording, this behavior was around 10% less often present than in the other recordings of this phase.

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

The presence of all the primary layer behaviors increased between phases, as can be seen in the last column of **Table 5**. For three behaviors (*imitation, mutual attention,* and *turn-taking*), the increase was relatively low: under 5%. However, *affective involvement* increased by almost 10% between phases.

At the secondary layer, we found the opposite pattern between behaviors. The presence of *joint attention* decreased largely by more than 7%, while the presence of *naming objects* increased a little (2%).

Dyad 4

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Four videos were recorded during baseline and three during follow-up. *Symbolic communication* and *perspective taking* were absent in the recordings of this dyad.

At the primary layer, the percentage of presence of *affective involvement* and *imitation* varied between 0 and 5% during baseline and follow-up recordings, as can be seen in **Table 6**. The presence of *mutual attention* and *turn-taking* was around 80%. Only in the third baseline recording and the first follow-up recording was this percentage much lower for both behaviors

TABLE 5 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 3.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	8.3	3.3	0	0	2.9	11.7	26.7	0	-	12.8	9.9
Imitation	15	13.3	3.3	11.7	10.8	15	16.7	15	-	15.6	4.8
Mutual attention	96.7	96.7	78.3	95	91.7	98.3	93.3	90	-	93.9	2.2
Turn-taking	96.7	96.7	78.3	95	91.7	98.3	93.3	88.3	-	93.3	1.6
Secondary layer											
Joint attention	38.3	10	31.7	28.3	27.1	8.3	30	21.7	-	20	−7.1
Naming objects	13.3	41.7	25	36.7	29.2	30	25	38.3	-	31.1	1.9

TABLE 6 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 4.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	5	5	0	1.7	2.9	0	5	5	-	3.3	0.4
Imitation	3.3	0	0	1.7	1.3	1.7	1.7	1.7	-	1.7	0.4
Mutual attention	83.3	76.7	45	80	71.3	61.7	88.3	80	-	76.7	5.4
Turn-taking	83.3	76.7	43.3	81.7	71.3	61.7	83.3	76.7	-	73.9	2.6
Secondary layer											
Joint attention	30	35	15	71.7	37.9	31.7	45	50	-	42.2	4.3
Naming objects	0	1.7	3.3	6.7	2.9	1.7	6.7	5	-	4.4	1.5

(around 40% in the baseline recording and 60% in the follow-up recording).

At the secondary layer, we found quantitative differences between the two behaviors. *Joint attention* was present more frequently (around 40%) than *naming objects* (around 5%) in both phases. The percentages of presence of both secondary layer behaviors is comparable between follow-up recordings. At baseline, the presence of *joint attention* was relatively low in the third recording (15%) and relatively high in the fourth (71.3%).

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

At the primary layer, we found few differences between phases (see last column of **Table 6**). The behaviors *affective involvement*, *turn-taking* and *imitation* increased by just 0.4–2.6%. The increase of *mutual attention* was a little higher: 5.4% between phases. The increase between phases was also small at the secondary layer: 4.3% for *joint attention* and 1.5% for *naming objects*.

Dyad 5

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Four videos were recorded during baseline and four during follow-up. All LCM behaviors were present for this dyad.

Both *affective involvement* and *imitation* were infrequently present in the baseline and follow-up recordings (around 5%), with the exception of the second follow-up recording for *imitation* (14.4%). The presence of *mutual attention* and *turn-taking* was much higher (just over 90%) in recordings of both phases (see **Table 7**).

We also found a difference in presence between the two secondary layer behaviors. The presence of *joint attention* varied around 70%, while *naming objects* fluctuated between 30 and 54%. *Joint attention* was relatively infrequently present in the first baseline recording (45.6%).

Large quantitative difference between behaviors were also found at the tertiary layer. The presence of *symbolic communication* varied around 10% between all recordings, while *perspective taking* was completely absent in the baseline recordings and some of the follow-up recordings. The presence of both behaviors was stable across recordings per phase.

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

At the primary layer, differences between recordings of the two phases were small (see **Table 7**). Half of the primary layer behaviors were less frequently present during the combined follow-up recordings than in the baseline recordings. Both increases and decreases were small, around 1–2%.

TABLE 7 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 5.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	0	0	1.1	3.3	1.1	0	0	0	1.1	0.3	−0.8
Imitation	3.3	5.6	4.4	4.4	4.4	3.3	14.4	5.6	2.2	6.4	2
Mutual attention	90	91.1	90	87.8	89.7	92.2	96.7	87.8	90	91.7	2
Turn-taking	87.8	94.4	95.6	93.3	92.8	94.4	93.3	88.9	90	91.7	−1.1
Secondary layer											
Joint attention	45.6	77.8	83.3	78.9	71.4	78.9	78.9	68.9	64.4	72.8	1.4
Naming objects	34.4	30	42.2	44.4	37.8	44.4	48.9	50	54.4	49.4	11.6
Tertiary layer											
Symbolic communication	12.2	3.3	12.2	7.8	8.9	14.4	6.7	15.6	10	11.7	2.8
Perspective taking	0	0	0	0	0	3.3	0	5.6	0	2.2	2.2

At the secondary and tertiary layers, all the behaviors increased between phases. Three behaviors increased by only 1–3% between phases, but *naming objects* increased by 11.6%.

Dyad 6

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Four videos were recorded during baseline and three during follow-up. All LCM behaviors were present for this dyad.

At the primary layer, the low presence of *affective involvement* stands out (see **Table 8**). In both phases, the presence of this behavior varied around 4% and was even completely absent in two follow-up recordings. *Imitation* was present in around 20% of the intervals in all recordings. The presence of *mutual attention* and *turn-taking* was much higher: in both phases the presence was over 90%, with the exception of the third baseline recording (84.4%) and the second follow-up recording (around 76.7%).

Joint attention was present in more than 90% of four recordings. At the baseline, the presence of this behavior was 10% lower in the third and fourth recordings, and during follow-up its presence was almost 30% lower in the third recording. *Naming objects* varied around 50% in all recordings, and the presence of this behavior was relatively stable between recordings in each phase.

At the tertiary layer, there were large quantitative differences between behaviors. *Perspective taking* was absent in almost all the recordings, while *symbolic communication* was present in around 35% of the intervals in each recording. The presence of *symbolic communication* was relatively low in the fourth baseline recording (23.3%).

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

All behaviors at the primary and secondary layers decreased between baseline and follow-up. Most of these decreases were small (between 0.6 and 3.2%), but *imitation* was present 6.5% less often during follow-up than during baseline recordings (see **Table 8**). The behaviors at the tertiary layer were present more often during follow-up, but this increase was very small for both behaviors (around 1%).

Dyad 7

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Three videos were recorded during baseline and follow-up for this dyad. All eight LCM behaviors were coded.

At the primary layer, the presence of *affective involvement* was a little unstable between recordings (varied between 4 and 21%). The presence in the first baseline recording was relatively low (4.4%) and the first follow-up recording was 10% lower than the other recordings in that phase (see **Table 9**). The presence of *imitation* was more stable between the different recordings in each phase. However, the 47.8% presence of this behavior in the third baseline recording was 20% higher than in the other two recordings of that phase. *Mutual attention* and *turn-taking* were present in almost 100% of the third baseline recording and all follow-up recordings. Both behaviors were present almost 15% less often in the first two baseline recordings.

At the secondary layer, quantitative differences were found between behaviors and phases. The presence of *joint attention* varied around 70% during baseline recordings and around 50% during follow-up recordings. This behavior was less often present during the first baseline recording than in the other recordings of that phase. The presence of *naming objects* varied around 80% in the baseline recordings (with an outlier of 93.3% in the third recording) and was present at around 90% in all follow-up recordings.

At the tertiary layer, large quantitative differences between the two behaviors and between phases could also be found. During baseline recordings, the presence of *symbolic communication* was about 70%, with the exception of the second recording (51% presence). During follow-up, the presence of this behavior was stable across recordings (around 88%). *Perspective taking* had one divergent result in each phase. The presence of that behavior was around 15% in the last two baseline recordings, while it was present in only 2% of the intervals in the first recording.

TABLE 8 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 6.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	1.1	4.4	1.1	4.4	2.8	0	0	4.4	-	1.5	−1.3
Imitation	30.0	26.7	15.6	23.3	23.9	15.6	15.6	21.1	-	17.4	−6.5
Mutual attention	98.9	96.7	84.4	91.1	92.8	100	76.7	100	-	92.2	−0.6
Turn-taking	98.9	95.6	84.4	91.1	92.5	98.9	75.6	100	-	91.5	−1
Secondary layer											
Joint attention	93.3	94.4	77.8	77.8	85.8	93.3	66.7	95.6	-	85.2	−0.6
Naming objects	63.3	55.6	57.8	57.8	58.6	52.2	45.6	67.8	-	55.2	−3.4
Tertiary layer											
Symbolic communication	38.9	34.4	44.4	23.3	35.3	34.4	37.8	34.4	-	35.6	0.3
Perspective taking	0	0	0	0	0	0	0	3.3	-	1.1	1.1

TABLE 9 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 7.

	Baseline recordings				Follow-up recordings				Difference
	1	2	3	Avg	1	2	3	Avg	
Primary layer									
Affective involvement	4.4	17.8	14.4	12.2	8.9	20	21.1	16.7	4.5
Imitation	15.6	27.8	47.8	30.4	31.1	38.9	40	36.7	6.3
Mutual attention	82.2	85.6	100	89.3	98.9	98.9	98.9	98.9	9.6
Turn-taking	82.2	84.4	100	88.9	98.9	98.9	98.9	98.9	10
Secondary layer									
Joint attention	56.7	68.9	73.3	66.3	48.9	47.8	53.3	50	−16.3
Naming objects	73.3	78.9	93.3	81.8	95.6	91.1	96.7	94.5	12.7
Tertiary layer									
Symbolic communication	68.9	51.1	76.7	65.6	83.3	90	92.2	88.5	22.9
Perspective taking	2.2	15.6	17.8	11.9	18.9	34.3	37.8	30.3	18.5

During follow-up recordings, the presence of *perspective taking* was also lower in the first recording (18.9%) than in the other two recordings (around 35%).

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

All primary layer behaviors increased between phases. Three behaviors increased greatly, with percentages between 6.3 and 10% (*imitation*, *mutual attention,* and *turn-taking*). *Affective involvement* increased by just under 5% between phases (see **Table 9**).

At the secondary layer, large differences between phases were also found, but in opposite directions for the two behaviors. The presence of *naming objects* increased greatly by 12.7%, but *joint attention* decreased by 16.3% between phases.

The largest differences between phases were found for the presence of tertiary layer behaviors. Both *symbolic communication* (22.9%) and *perspective taking* (18.5%) were present much more often in the follow-up recordings than in the baseline recordings.

Dyad 8

Presence of the LCM Behaviors During Baseline and Follow-Up Recordings

Four videos were recorded during baseline and follow-up. All eight LCM behaviors were coded for this dyad.

At the primary layer, the large difference in the presence of *affective involvement* during baseline recordings stands out (see **Table 10**). The presence of this behavior was around 25% in the first two baseline recordings, while its presence was just 2% in the last two baseline recordings. Quantitative differences between follow-up recordings were smaller (between 8 and 16% presence). The presence of the three other primary layer behaviors was more stable. *Imitation* was present around 35% in each baseline recording and around 43% in all follow-up recordings. The presence of *mutual attention* and *turn-taking* was just under or at 100% in all recordings from both phases.

At the secondary layer, there were differences in presence between behaviors. *Joint attention* was present about 30% less often than *naming objects* in most recordings. The presence of this behavior was stable across baseline recordings (around 55%). During follow-up, the presence of this behavior in the first

TABLE 10 | Percentage presence of LCM behaviors and difference in presence between baseline and follow-up recordings for dyad 8.

	Baseline recordings					Follow-up recordings					Difference
	1	2	3	4	Avg	1	2	3	4	Avg	
Primary layer											
Affective involvement	21.1	28.9	2.2	2.2	13.6	7.8	7.8	16.7	15.6	12	−1.6
Imitation	38.9	37.8	34.4	28.9	35	42.2	38.9	37.8	52.2	42.8	7.8
Mutual attention	97.8	100	98.9	92.2	97.2	100	97.8	97.8	100	98.9	1.7
Turn-taking	96.7	100	98.9	88.9	96.1	100	97.8	97.8	98.9	98.6	2.5
Secondary layer											
Joint attention	46.7	61.1	60	52.2	55	14.4	32.2	61.1	50	39.4	−15.6
Naming objects	88.9	90	82.2	88.9	87.5	95.6	94.4	87.8	96.7	93.6	6.1
Tertiary layer											
Symbolic communication	80	72.2	64.4	78.9	73.9	93.3	85.6	70.0	92.2	85.3	11.4
Perspective taking	18.9	14.4	11.1	17.8	15.6	20	20	22.2	34.4	24.2	8.6

recordings was low compared to the other recordings in this phase (14.4% compared to around 50%). No divergent results were found for the presence of *naming objects* in either phase. The presence of this behavior was around 88% in baseline recordings and around 94% in follow-up recordings.

At the tertiary layer, *symbolic communication* was present much more often than *perspective taking* (around 80% compared to around 20%). The presence of both behaviors was stable across baseline recordings. During follow-up recordings, *symbolic communication* was present 15% less often in the third recording and *perspective taking* was present almost 15% more often in the fourth recording.

Difference in Presence of the LCM Behaviors Between the Combined Recordings of the Baseline and Those of the Follow-Up

At the primary layer, differences in presence between phases were small for three of the four behaviors. *Mutual attention* and *turn-taking* increased, but by only 2 and 3%, and *affective involvement* decreased by just 2%. *Imitation* is the only behavior that increased more during the phases, by 7.8% (see **Table 10**).

At the secondary layer, there were large differences between the two behaviors. The presence of *joint attention* decreased by almost 16%, while the presence of *naming objects* increased by 6%.

At the tertiary layer, we found two large increases between phases. *Symbolic communication* was present 11.4% more often during follow-up, and *perspective taking* increased by 8.6%.

Group Analysis

Presence of the LCM Behaviors During Baseline and Follow-Up

At the primary layer of the LCM, the largest percentage differences in presence were found between LCM behaviors. For each dyad, the presence of *affective involvement* (0–32%) and *imitation* (1–43%) was much lower than the presence of *mutual attention* and *turn-taking* (71–100% for both behaviors). Differences between dyads were small at this layer (see **Table 11**). The presence of *affective involvement* was relatively high in both baseline and follow-up recordings for dyad 2 (29 and 32%) compared to the other dyads (0–17%). The presence of *imitation* stayed under 20% for more than half of the dyads in recordings of both or one of the phases (dyads 1, 2, 3, 4, 5, and 6). For dyads 6, 7, and 8, *imitation* was present in more than 20% of the recordings, and even more than 30% for dyads 7 and 8. *Mutual attention* and *turn-taking* were present in more than 80% of the recordings of both phases for every dyad except dyad 4.

At the secondary layer, there were differences between behaviors and between dyads. For half of the dyads, *joint attention* was present more often than *naming objects* in both phases (dyads 2, 4, 5, and 6). In dyad 1, the presence of both behaviors was equal in the baseline recordings, but *joint attention* was more often present than *naming objects* in the follow-up recordings. There were large differences in the percentage of presence between dyads for both behaviors. The presence of *joint attention* was under 50% for dyads 1, 3, 4, and 8 in the follow-up recordings, while it was more than 50% for dyads 2, 5, 6, and 7, up to more than 80% for dyad 6 in both phases. *Naming objects* showed even larger differences between dyads. The presence of this behavior was under 5% for dyad 4, while it is was more than 80% present for dyads 7 and 8 in the recordings of both phases.

At the tertiary layer, we found even clearer differences between behaviors and dyads. Both behaviors were absent in all the recordings for dyads 1, 2, 3, and 4. For dyads 5 and 6, *perspective taking* was absent in only the baseline recordings. For dyads 5, 6, 7, and 8, *symbolic communication* was more often present than *perspective taking* in both phases. We found large differences between the four dyads for *symbolic communication*: its presence was only around 10% for dyad 5 and around 80% for dyad 8. The presence of *perspective taking* varied between 0 and 30% among dyads 5 through 8.

Difference in Presence of the LCM Behaviors Between Baseline and Follow-Up

At the primary layer, most increases between phases were around or lower than 5% (see **Table 12**). There were a few exceptions: dyad 2 on *imitation* (11.9%), dyad 7 on *turn-taking* (10%) and

TABLE 11 | Mean percentage of presence for each LCM behavior during baseline (BL) and follow-up (FU) recordings.

	Phase	Primary layer behaviors				Secondary layer behaviors		Tertiary layer behaviors	
		Affective involvement	Imitation	Mutual attention	Turn-taking	Joint attention	Naming objects	Symbolic communication	Perspective taking
Dyad 1	BL	5	21	81	80	23	23	0	0
	FU	6	19	83	82	39	31	0	0
Dyad 2	BL	29	16	99	99	61	17	0	0
	FU	32	28	100	100	50	22	0	0
Dyad 3	BL	3	11	92	92	27	29	0	0
	FU	13	16	94	93	20	31	0	0
Dyad 4	BL	3	1	71	71	38	3	0	0
	FU	1	2	77	74	42	4	0	0
Dyad 5	BL	1	4	90	93	71	38	9	0
	FU	0	6	92	92	73	49	12	2
Dyad 6	BL	3	24	93	93	86	59	35	0
	FU	2	17	92	92	85	55	36	1
Dyad 7	BL	12	30	89	89	66	82	66	12
	FU	17	37	99	99	50	95	89	30
Dyad 8	BL	14	35	97	96	55	88	74	16
	FU	12	43	99	99	39	94	85	24

mutual attention (9.6%), and dyad 3 on *affective involvement* (9.9%). The largest decrease was found for dyad 6 on *imitation*: this behavior was present 6.5% less often in follow-up recordings than in the baseline recordings. The other decreases varied between 1 and 4% and were mainly found in dyads 5 and 6.

At the secondary layer, the presence of *joint attention* decreased for five out of eight dyads. The largest decrease was found for dyad 7: *joint attention* dropped by more than 16% between baseline and follow-up recordings. On the other hand, the presence of *naming objects* increased for all but one dyad: only for dyad 6 was this behavior present less frequently during follow-up (−3.4%). *Naming objects* increased most for dyad 7, by almost 13%.

At the tertiary layer, the presence of both behaviors increased between baseline and follow-up recordings for all four dyads for which these behaviors were present. The increase for both behaviors was small for dyads 5 and 6 (around 2%). The largest increases were found for dyad 7: *symbolic communication* was found almost 23% more often in follow-up recordings than in baseline recordings, and the presence of *perspective taking* increased by over 18%.

This study analyzed the presence of different behaviors from the Layered Communication Model (LCM) before and after an intervention was conducted, in order to evaluate the use of the LCM as a tool to describe a dyad's communicative level and as a tool to monitor communication development over time. As expected, quantitative differences were found between the primary layer behaviors; *affective involvement* and *imitation* were less often present compared to *shared attention* and *turn-taking*. Contrary to earlier findings, differences were also found between dyads for the presence of *affective involvement* and *imitation*. Findings at the secondary and tertiary layer were as expected and comparable to earlier findings, which means that secondary layer behaviors were more often present compared to tertiary layer behaviors, and all behaviors from these two layers were more often present for students with higher developmental ages compared to those with lower developmental ages.

In terms of development over time, we expected that the degree of improvement in presence of behaviors would depend on the dyads' communicative level during baseline recordings. We expected that primary layer behaviors would increase more for students with lower developmental ages (that did not show tertiary layer behaviors) and expected these behaviors to increase less for dyads with higher developmental ages. Such differences between dyads were not found; the increase in presence of primary layer behaviors was comparable between dyads and relatively low. All things considered, we noticed a pattern of substantial improvement over time and across the dyads, next to layer-related differences indicative of more substantial improvement at the secondary and tertiary layer behaviors.

DISCUSSION

The aim of this study was to find out whether the LCM could be used not only as a tool to describe a dyad's communicative level, but also as a tool to monitor communication development over time. Results will be discussed for both parts of this study's aim.

Describing the Communication Level of a Dyad Using the LCM

The first part of this study is a replication of an earlier study (Wolthuis et al., 2019 on the use of the LCM as a tool to describe a dyads communication level. Given the exploratory nature of

TABLE 12 | Difference between the percentage of presence of the behaviors during baseline and follow-up.

	Primary layer behaviors				Secondary layer behaviors		Tertiary layer behaviors	
	Affective involvement	Imitation	Mutual attention	Turn-taking	Joint attention	Naming objects	Symbolic communication	Perspective taking
Dyad 1	1.4	−2	1.1	1.7	15.3	7.7	X	X
Dyad 2	3.2	11.9	0.7	1.1	−10.8	4.5	X	X
Dyad 3	9.9	4.8	2.2	1.6	−7.1	1.9	X	X
Dyad 4	0.4	0.4	5.4	2.6	4.3	1.5	X	X
Dyad 5	−0.8	2	2	−1.1	1.4	11.6	2.8	2.2
Dyad 6	−1.3	−6.5	−0.6	−1	−0.6	−3.4	0.3	1.1
Dyad 7	4.5	6.3	9.6	10	−16.3	12.7	22.9	18.5
Dyad 8	−1.6	7.8	1.7	2.5	−15.6	6.1	11.4	8.6
Dyads combined	2.2	3.5	2.4	2.1	−4.8	5.9	9.4	7.6

that study, more research was needed with more dyads, especially since people with CDB form a very heterogeneous population. As such, replication is an important tool in research to increase the generalizability of results, especially in (multiple) single-case studies (Barlow et al., 2009).

Like in the study of Wolthuis et al. (2019) we found that the presence of primary layer behaviors was comparable between the dyads with students of different developmental ages. This confirmed the suggestion of Janssen et al. (2003) that this layer of the LCM serves as a basis for communication. *Within* the primary layer, Wolthuis et al. (2019) found quantitative differences between the primary layer behaviors *affective involvement* and *imitation* on the one hand, and *mutual attention* and *turn-taking* on the other hand. The present study also demonstrated differences between dyads in the presence of the behaviors of *affective involvement* and *imitation.*

We found no clear pattern between the students' developmental ages and the divergent presence of these behaviors. *Affective involvement* was most present for dyad 2 and least so for dyad 5 (the dyads were numbered based on the students' developmental ages). No pattern of increase was found in the presence of *imitation* from dyad 1 to dyad 8 either. These results show that the presence of these behaviors appears to be independent of the student's developmental age. An explanation would be that the presence of *affective involvement* is dependent on the chosen activity, which could be emotionally loaded (like singing songs for dyad 2) or have an emotionally loaded content (like the conversations in dyads 7 and 8). *Imitation* appears to be dependent on the behavior's function, which could be to maintain lively communication (cf. Hart, 2006) or confirm others' behaviors (cf. Janssen et al., 2003, 2010; Damen et al., 2011; Bloeming-Wolbrink et al., 2018). This behavior was present relatively often in dyads 6, 7, and 8, which used (tactile) sign language and often imitated the signs of the other as a means of confirmation. Results show that *imitation* was used more often in this manner than when its sole function was to maintain lively communication.

As in the study by Wolthuis et al. (2019), we found quantitative differences within and between the secondary and tertiary layer behaviors. The differences reflect the developmental pattern of the model that was based on the three subsequent layers of development as described by Bråten and Trevarthen (2007). Secondary layer behaviors were more often present compared to tertiary layer behaviors, and within layers the presence of *joint attention* was higher than *naming objects*, and *symbolic communication* was more often present compared to *perspective taking* for most dyads. Two dyads showed an opposite pattern at the secondary layer. This was in dyads 7 and 8, where *joint attention* was less often present compared to *naming objects.* This can be explained by the fact that these students have a large (tactile) sign language vocabulary. They are less reliant on pointing at, showing, or touching an object to communicate about it, which is evident in the lower percentages for *joint attention* and higher percentages for *naming objects*. Such a change in the use of joint attention can also be found for typically developing children around 18 months (which is at the start of the secondary layer of the LCM), when they rapidly start learning new words and use joint attention in a different way (Carpenter et al., 1998).

Monitoring Communication Development Using the LCM

The second aim of this study was to analyze the use of the LCM as a tool to monitor development over time. For this purpose, a comparison was made between videos recorded at the start of this study and 5 months later. Contrary to the study of Wolthuis et al. (2019), increases in presence of behaviors over time were found. This was found for almost all dyads, regardless of the differences in developmental ages of the students.

At the primary layer, LCM behaviors increased between phases for most dyads, but in small amounts (mainly between 0 and 5%). For dyads with a low presence or absence of secondary and tertiary layer behaviors in the baseline recordings, we expected the presence of primary layer behaviors to increase more between phases than it would for dyads with a higher presence of secondary and tertiary layer behaviors at the baseline. Our results show that secondary layer behaviors were less often present for the first four dyads and tertiary layer behaviors were completely absent. When comparing dyads 1, 2, 3, and 4 to dyads, 5, 6, 7, and 8, in terms of the increase

of primary layer behaviors between phases, we only found (small) increases between phases for the first four dyads (an exception is *imitation* in dyad 1). For the latter four dyads, results show both increases and decreases between phases, but the percentages are also low. This implies that even though the presence of primary layer behaviors more often increased for students with lower developmental ages, the presence of these behaviors also increased for students with higher developmental ages. This is in line with the assumption of Bråten and Trevarthen (2007) that behaviors of lower layers do not disappear when higher layer behaviors develop, and that these behaviors can be supported and improved regardless of students' developmental ages.

At the secondary layer, a change between phases was found in opposite directions for the presence of *joint attention* and *naming objects* in more than half of the dyads, suggesting a relationship between these behaviors. In all dyads where we observed a decrease in *joint attention*, *naming objects* increased between phases. This can be explained by the fact that when dyads use more words or signs to communicate, they need fewer objects to directly refer to, which can be seen in lower frequencies of *joint attention* and higher frequencies for *naming objects*. Instead of using the object to support communication, these dyads used words and signs to communicate about objects and people. This is further supported by the earlier mentioned finding that *joint attention* was more often present than *naming objects* for all but two dyads (dyads 7 and 8). Those two dyads used sign language often and could therefore use *naming objects* rather than required *joint attention* toward objects or others to communicate about them.

On the other hand, the decrease of *joint attention* for most dyads between phases can also be related to how this behavior was defined in the coding scheme. *Joint attention* was coded as present when an object was in sight and shared between student and teacher while, in a broader sense, *joint attention* could also mean the sharing of a mental representation of an object or person. Since it is difficult to objectively determine in video recordings whether a mental representation of something is shared, we choose to score instances of *joint attention* only when objects or people were present in the video. It could be argued that if we had used the broader definition, we might have found less of a decrease in *joint attention* between phases. Both explanations for the decrease in *joint attention* show that a decrease in this behavior does not necessarily signify a negative impact on communication development.

Tertiary layer behaviors were present in half the dyads, and there was an increase between phases for each of those dyads. Since an earlier study that analyzed recordings when no intervention was involved (Wolthuis et al., 2019) found no such communication improvement, this increase could have been caused by the intervention that was conducted between phases. This is especially convincing for the large increases in *symbolic communication* and *perspective taking* we found for dyads 7 and 8. Since this is the first study to analyze this, further research is needed to confirm the relationship between the intervention and the increase in presence of these behaviors.

Methodological Reflection and Recommendations

This study used a quantitative method to describe communication development among students with CDB in videos that were recorded with a 5-months interval. The presence of different LCM behaviors was analyzed and compared between dyads that included students of different developmental ages, using the same method as an earlier study by Wolthuis et al. (2019).

Both the exploratory nature of that study and the use of single case studies required more research to confirm its findings. The analysis of more participants and the fact that results were in line with earlier research increased the generalizability of the results of the current study (Barlow et al., 2009). The replicative part of our study helped to build evidence for the use of the LCM as a tool to describe a dyad's communicative level.

Furthermore, the current study was used to find out whether the LCM can be used as a tool to monitor communication development over time. Based on earlier research that suggested that single moments in time are not always a good representation of a dyad's potential (Damen, 2015; Wolthuis et al., 2019), we chose to make multiple recordings for the baseline and follow-up phases of this study. Results showed that the LCM can be used to monitor development when different recordings are combined per phase. Even though we found a comparable presence of behaviors between the different recordings per phase for many dyads, there were exceptions on some behaviors, which further underlines the importance of making multiple recordings to describe and monitor a dyad's communication level.

Since the current study focused on the use of the LCM as a tool to describe and monitor communication, it did not describe and analyze the intervention that was conducted between baseline and follow-up. For some dyads, increases in presence between phases were large, especially at the secondary and tertiary layer, which suggests a relationship between increase in presence and the intervention. It is recommended for future research to analyze the contents of the intervention to find out what actually caused the increase of certain behaviors. This would help to understand whether the LCM can also be used as a tool to *improve* communication. Secondary and tertiary layer behaviors seem most suitable for further analysis, since their presence increased the most between phases.

This study used a coding schema to analyze 10-s intervals in order to measure the presence of different communicative behaviors. This method is useful for research purposes, since it increased the reliability of the study, but it is also time-consuming. More research is needed to translate the coding schema into a tool that can be used in practice. For professionals working with people with CDB, the layers and behaviors of the LCM (as described in **Table 1**) can be used to analyze and describe the communication between themselves and people with CBB. Infrequently present behaviors can be used as a starting point for improving communication.

In conclusion, the LCM showed to be a functional research tool that can help to gain insights in a dyads' communicative

level and to monitor development. More insights in the use of an intervention based on the LCM is needed to analyze the LCM as a tool to improve communication as well.

DATA AVAILABILITY STATEMENT

The datasets generated for this article are not readily available in order to protect the privacy of the participants. Requests to access the datasets should be directed to Kirsten Wolthuis, k.wolthuis@rug.nl.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee for Pedagogical & Educational Sciences University of Groningen. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

KW, AM, GB, and MJ contributed to the conception and design of the study. KW gathered the data, organized the database, analyzed the data, and wrote the first draft of the manuscript. AM, GB, and MJ revised the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This study is part of a Ph.D. project funded by NutsOhra, registered under project number 1302-008 and Royal Dutch Kentalis.

REFERENCES

Ashurst, D., Bamberg, E., Barrett, J., Bisno, A., Burke, A., Chambers D., et al. (1985). *Southern California Ordinal Scales of Development*. North Hollywood, CA: Foreworks.

Barlow, D. H., Nock, M. K., and Hersen, M. (2009). *Single Case Experimental Designs: Strategies for Studying Behavior Change.* 3rd ed. Boston, MA: Pearson.

Bloeming-Wolbrink, K.A., Janssen, M. J., Ruijssenaars, A. J. J. M., and Riksen-Walraven, J. M. (2018). Effects of an intervention program on interaction and bodily emotional traces in adults with congenital deafblindness and an intellectual disability. *J. Deafblind Stud. Commun.* 4, 39–66. doi: 10.21827/jdbsc.4.31376

Bråten, S., and Trevarthen, C. (2007). "Prologue: from infant intersubjectivity and participant movements to stimulation and conversation in cultural common sense," in *On Being Moved. From Mirror Neurons to Empathy,* ed S. Bråten. (Amsterdam: John Benjamins Publishing Company), 22–34. doi: 10.1075/aicr.68.04bra

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., and Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monogr. Soc. Res. Child Dev.* 63:i-174. doi: 10.2307/1166214

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educ. Psychol. Measure.* 20, 37–46. doi: 10.1177/001316446002000104

Dalby, D. M., Hirdes, J. P., Stolee, P., Strong, J. G., Poss, J., Tjam, E. Y., et al. (2009). Characteristics of individuals with congenital and acquired deaf-blindness. *J. Vis. Impair. Blindness* 103, 93–102. doi: 10.1177/0145482X0910300208

Damen, S. (2015). *A matter of meaning. The effect of partner support on the intersubjective behaviors of individuals with congenital deafblindness*. (Doctoral dissertation). University of Groningen, Groningen, Netherlands.

Damen, S., Janssen, H. J. M., Ruijssenaars, W. A. J. J. M., and Schuengel, C. (2015). Intersubjectivity effects of the high-quality communication intervention in people with deafblindness. *J. Deaf Stud. Deaf Educ.* 20, 191–201. doi: 10.1093/deafed/env001

Damen, S., Kef, S., Worm, M., Janssen, M., and Schuengel, C. (2011). Effects of video-feedback. Interaction training for professional caregivers of children and adults with visual and intellectual disabilities. *J. Intellect. Disabil. Res.* 55, 581–595. doi: 10.1111/j.1365-2788.2011.01414.x

Dammeyer, J. (2010). Prevalence and aetiology of congenitally deafblind people in Denmark. *Int. J. Audiol.* 49, 76–82. doi: 10.3109/14992020903311388

Dammeyer, J. (2014). Deafblindness: a review of the literature. *Scand. J. Public Health* 42, 554–562. doi: 10.1177/1403494814544399

Fukkink, R.G., Trienekens, N. and Kramer, L. J. C. (2011). Video feedback in education and training: putting learning in the picture. *Educ. Psychol. Rev.* 23, 45–63. doi: 10.1007/s10648-010-9144-5

Gast, D. L., and Hammond, D. (2010). "Withdrawal and reversal designs," in *Single Subject Research Methodology in Behavioral Sciences,* ed D. L. Gast. (New York, NY: Routledge), 234–275. doi: 10.4324/9780203877937-10

Hart, P. (2006). Using imitation with congenitally deafblind adults: establishing meaningful communication partnerships. *Infant Child Dev.* 15, 263–274. doi: 10.1002/icd.459

Janssen, M. J., Riksen-Walraven, J. M., and Van Dijk, J. P. M. (2003). Toward a diagnostic intervention model for fostering harmonious interactions between deafblind children and their educators. *J. Vis. Impairment Blindness* 97, 197–214. doi: 10.1177/0145482X0309700402

Janssen, M. J., Riksen-Walraven, J. M., van Dijk, J. P. M., and Ruijssenaars, W. A. J. J. M. (2010). Interaction coaching with mothers of children with congenital deaf-blindness at home: applying the diagnostic intervention model. *J. Vis. Impairment Blindness* 104, 15–29. doi: 10.1177/0145482X1010400106

Kentalis (2017). *Handboek Handelingsgericht Arrangeren [Handbook of Action-Based Arrangements]*. Sint-Michielsgestel: Kentalis.

Klenowski, V. (1995). Student self-evaluation processes in student-centred teaching and learning contexts of Australia and England. *Assess. Educ.* 2, 145–163. doi: 10.1080/0969594950020203

MacLaren Chorney, J., McMurtry, C. M., Chambers, C. T., and Bakeman, R. (2014). Developing and modifying behavioral coding schemes in pediatric psychology: a practical guide. *J. Pediatr. Psychol.* 40, 154–164. doi: 10.1093/jpepsy/jsu099

Prain, M. I., McVilly, K. R., and Ramcharan, P. (2012). Being reliable: issues in determining the reliability and making sense of observations of adults with congenital deafblindness? *J. Intellect. Disabil. Res.* 56, 632–640. doi: 10.1111/j.1365-2788.2011.01503.x

Ross, J. A. (2006). The reliability, validity, and utility of self-assessment. *Pract. Assess. Res. Eval.* 11, 1–13. doi: 10.7275/9wph-vv65

Ruiter, S. A. J., Van der Meulen, B. F., Lutje Spelberg, H. C., and Smrkovsky, M. (2003). Bayley scales of infant development - II - Nederlandse versie (BSID-II-NL). *Vlaams Tijdschrift Voor Orthopedagogiek* 1, 37–38.

Tellegen, P. J., and Laros, J. A. (2011). *Snijders-Oomen niet-verbale intelligentietest (SON-R 2½-7).* Amsterdam: Hogrefe.

UNESCO (1994). *Final report – World conference on special needs education: Access and quality*. Paris: UNESCO.

Wolthuis, K., Bol, G. W., Minneart, A., and Janssen, M. J. (2019). Communication development from an intersubjective perspective: exploring the use of a layered communication model to describe communication development in students with congenital deafblindness. *J. Commun. Disord.* 80, 35–51. doi: 10.1016/j.jcomdis.2019.04.001

World Health Organization (2001). *The World Health Report 2001. Mental health: New Understanding, New Hope*. Geneva: WHO.

World Health Organization (2003). *International Statistical Classification of Diseases and Related Health Problems (10th revision)*. Available online at: http://www.who.int/classifications/icd/en/ (accessed March, 2020).

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.