

Environment and language experience in deaf children's theory of mind development

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Identifying when children start to understand others

We focus in this chapter on the human social cognitive ability to connect with each other at the level of different inner and unobservable mental states such as knowledge and beliefs; a development encapsulated in the term *theory of mind* (ToM). The development of children's ToM has been a major research topic for the last 30 years and recently attention has turned to the environmental enablers of social cognition found in early parent-child interaction. The question of how nature and nurture influence ToM development resembles, and is closely related to, the long-standing debate in research on language acquisition. While there are clear biological factors inherent in child language development (e.g., a bias for neonates to do analyses of statistical frequency of phonemes; see Saffran, Aslin, & Newport, 1996) there is also a strong cultural influence. All children need linguistic communication and interaction with adults to develop native language skills, although the timing and extent of such input is still controversial. Research on hearing bilingual infants is instructive in this respect. For example, in a recent longitudinal study of language acquisition, Garcia-Sierra, Rivera-Gaxiola, Percaccio, Conboy, Romo, Klarman, Ortiz, and Kuhl, (2011) found that bilingual children were perceptually open to phonetic contrasts longer than monolingual infants, a clear effect of communicative experiences on early language learning. Similarly, research is divided on the extent of biological and cultural influence on the development of children's ToM (Heyes & Frith, 2014).

In this chapter we take advantage of recent research with deaf infants and toddlers to argue for the importance of very early language environments in the emergence of understanding others' behavior in terms of their mental states. An interesting finding from research on children born deaf is that while deaf children with deaf parents pass standard ToM tasks at age appropriate stages, deaf children of hearing parents have major delays in this aspect of social cognition. While the early literature focused on delays in language development as an explanation, more recent research has

looked at early environmental differences deaf children of hearing parents experience, especially disturbances in joint attention and impoverished interaction in conversations, as a cause of subsequent ToM deficits. We first describe a number of studies that have looked at ToM abilities both as an explicit verbal capacity and as an implicit non-verbal capacity in deaf and hearing children. We then explore the impact of variations in early environments between deaf and hearing children, which include differences in the establishment of joint attention, the content of conversations, and the connectedness of early interaction, and examine possible consequences of these environmental factors on social cognition. We conclude the chapter by examining some potential future directions, and describe aspects of current research that could be applied to intervention work.

Developing a theory of mind: implicit and explicit knowledge of others' minds

While the original article by Premack and Woodruff (1978) encompassed a wide range of mental state concepts – understanding emotions, motivational states and intentions – most subsequent work on ToM has focused on the concept of false belief. As such, ToM has become synonymous with a person's ability to predict what an actor is likely to do, based on what he or she believes or expects. There are differing theoretical views on how best to characterize children's development of ToM abilities and the role of language in this unfolding. Much research argues that ToM is dependent on access to linguistic features in terms of structure or content, or both. A strong linguistic hypothesis was put forward by de Villiers and Pyers (2002), who argued that before children could conceptualize false beliefs they need to have developed an understanding of the syntax necessary to embed one clause in another (termed sentence compliments) in non-mentalistic contexts; for example, Sally said that *the marble was in the basket*. Their argument was that by first

mastering the syntax of complementation linguistically, children would be able to manipulate the two clauses in an internal meta-representation of mental attitudes (de Villiers & Pyers, 2002).

Other researchers (e.g., Milligan, Astington, & Dack, 2007) have argued that rather than syntax, it is lexical development that enables children to think about mental states more explicitly. This research highlights the acquisition of vocabulary linked to mental state verbs – “to think, to know, to not know” and so on. Finally still other researchers have instead claimed that the key to understanding the role of language in children’s ToM development is to look not at their acquisition of formal properties (verb semantics, syntax etc.) but instead their experience of language and communication in conversation (Peterson & Siegal, 1995). This final framework focuses on how children come to develop the pragmatic skills necessary to understand conversations and interaction between themselves and others, and this interaction is thought to be the enabling conditions for ToM development.

However, up until recently these different lines of investigation have focused almost exclusively on how language enables ToM in passing *explicit* versions of the standard False Belief task e.g. Sally-Anne (Baron-Cohen, Leslie, & Frith, 1985). In the Sally-Anne task the experimenter uses the Sally doll to hide a marble in a basket in front of Anne’s view. Then Sally is removed from the test situation by telling the child that the doll had to go outside. While Sally is absent the experimenter uses the Anne doll to move a marble from the basket to a closable box. Now the experimenter brings back the Sally doll and the child is asked “Where will Sally look for her marble”? Wimmer and Perner (1983), using an analogous task to Sally-Anne called the Maxi task, argued that the ability to appreciate another person’s false belief went through a change during 4 - 6 years of age. While younger children answer that Maxi will look for his chocolate in a green cupboard, where it actually is, older children answer correctly that he will look for it in the original location, that is, in a blue cupboard, where he *believes* the chocolate to be.

The age at which children begin to solve false belief problems such as Maxi or Sally-Anne has been debated for many years. Some researchers argue it begins at 4 years of age (Perner & Wimmer, 1983; Baron-Cohen, Leslie, & Frith, 1985) while others have brought this down to the second half of the first year of life (Kovács, Téglás, & Endress, 2010; Onishi & Baillargeon, 2005; Southgate & Vernetti, 2014). On the basis of these more recent results, some cognitive scientists argue for a specific innate *social sense* that develops very early with little external input. The *social sense* view is empirically vindicated by studies employing infants' implicit, or spontaneous non-verbal behaviors such as pointing gestures, helping and preferential looking (Buttelmann, Carpenter & Tomasello, 2009; Southgate, Chevallier, & Csibra, 2010). Against the backdrop of such apparently early demonstrations of understanding mind, it has been argued that explicit verbal responses required in Sally-Anne type tasks make additional demands on children's limited executive functioning skills, which are dramatically reduced in non-verbal paradigms.

A typical non-verbal spontaneous-response looking time task shares with a verbally presented ToM task a test situation in which an agent who has not seen the displacement of an object holds a false belief about its location (e.g. Onishi & Baillargeon, 2005). However the infants' response is not verbal but measured by their preferential or anticipatory looking. Such looking patterns indicate an accurate expectation about the actor's search behavior. Although looking times are notoriously difficult to interpret and such studies have met with criticism (see Perner & Ruffman, 2005), there is now extensive evidence from several studies employing various tasks and dependent measures suggesting that infants' looking behaviors are consistent with the view that they are able to spontaneously attribute beliefs and belief-like states to ignorant agents (Baillargeon, Scott, & He, 2010; Buttelmann, Carpenter, & Tomasello, 2009; Senju, Southgate, Snape, Leonard & Csibra, 2013; Southgate, Chevallier, & Csibra, 2010).

In both verbal elicited-response and non-verbal spontaneous-response measures of ToM, deaf children of hearing parents with normal non-verbal IQ have been shown to have difficulties. At the same time, deaf children of deaf parents who use sign language when communicating with their children at home, perform well on traditional, explicit verbal ToM measures; their performance is in fact comparable to the level of hearing children (Woolfe, Want, & Siegal, 2002; Schick, P. de Villiers, J. de Villiers, & Hoffmeister, 2007). Because deaf children of hearing parents typically have language delay (both signed and spoken) the common explanation for ToM difficulties has been based in a disruption in the typical development of linguistic skills or communicative interaction. The results of many empirical studies with deaf children of hearing parents document that the developmental trajectory of performance on explicit verbal ToM is highly variable, often delayed and very dependent on the communicative experiences of the child (Meristo, Falkman, Hjelmquist, Tedoldi, Surian, & Siegal, 2007). In fact, deaf children from hearing homes often have difficulties with ToM which can persist up to teenage years and in some cases even among deaf adults (Pyers & Senghas, 2009). One reasonable explanation for this discrepancy between the two groups of deaf children might be that deaf children from hearing homes also have a delayed language development and might have difficulties in following the storyline or formulating an answer in the explicit kind of highly verbal tasks.

In our recent work (Meristo, Morgan, Geraci, Iozzi, Hjelmquist, Surian, & Siegal, 2012), we have therefore asked whether deaf infants from hearing homes who do not have access to daily fluent verbal interactions with their family members show a similar pattern of performance in various mentalizing tasks; that is, do they demonstrate an implicit, possibly innate, experience-independent social sense such as that suggested by Kovács, Téglás, & Endress (2010), Surian, Caldi and Sperber (2007), and Onishi and Baillargeon (2005)? To address this question, we have examined whether deaf infants from hearing homes show similar anticipatory looking to hearing

infants when the measures are simplified, administered on an eye tracker, and do not require verbal comprehension or responses to questions? Alternatively, anticipatory looking behaviors that are consistent with FB understanding may in fact be enabled through early joint interactions. If such early ToM behavior emerges as a function of social interaction there would be reason to expect that deaf children from hearing homes should show impairments in spontaneous-response ToM tasks. Thus, deaf children with varying linguistic experiences can illuminate in a novel way our understanding of the environmental preconditions of ToM in terms of perceptual, linguistic and cooperative affordances. Our findings showed that deaf 2-year-old children of hearing parents had difficulties with ToM using these implicit measures, unlike their age-matched hearing peers. It seems that deafness blocks the ability to use the innate social sense that has been argued for in previous implicit studies of ToM. Such findings suggest that there must be an environmental element involved in enabling false belief understanding. This work with deaf children coupled with other studies on environmental enablers of social cognition has moved the focus of attention of the developmental origins of ToM towards the interactions children take part in during the first two years of life. Deaf children of hearing parents fail implicit measures of false belief at 2 years while hearing peers pass these tasks, despite both groups having quite limited formal language skills (syntax and abstract vocabulary knowledge). This pattern of results suggests that the enablers of ToM might be more linked with differing environments and in particular adult-child communication differences.

As mentioned previously, the first studies of implicit mentalizing, such as Onishi and Baillargeon (2005) were met with criticism and also alternative interpretations of the empirical results. Perner and Ruffman (2005) suggested for example that the infant only needed to rely on neuronal learning, behavioural regularities and perceptual information, without imputing a mediating mind to the protagonists observed. This kind of criticism was recently revived by Heyes

(2014). In a review of studies of implicit ToM, she concluded that the empirical results interpreted as infant mindreading could be explained more simply by retroactive memory effects and low-level perceptual novelty, reflecting domain-general processes. That criticism also referred to the studies of deaf infants of hearing parents (Meristo et al. 2012). The group of deaf infants becomes interesting as a possibility for delineating the genesis of mentalizing.

It is difficult to see why deaf children of hearing parents should not have attained the same kind of memory/perceptual mechanisms that same age hearing children have, if looked at in the perspective of Heyes's (2014) framework. Especially if one assumes a domain-general mechanism explaining infants' behaviour. It seems that a minimum, but crucial, conversational influence in early environments is necessary to account for the fact that 24-month-old hearing infants, but not same-aged deaf infants of hearing parents, at least behave as if (according to Heyes, 2014) they imputed a mind to the protagonists observed (Meristo et al., 2012). In a non-mentalising framework, one would have to assume some domain-general deficit among that group of deaf children. This could be the case, but there is little, if any, evidence speaking in favour of this possibility. Alternatively, as Hayes (2014) claims, it could be that the looking pattern of deaf infants is due to that they were less distracted than hearing infants of the same age (supplementary material, p.7). So far this claim is unfounded, and it seems more parsimonious to assume that typically developing infants no later than around two years of age do ascribe mental states to observed agents, and that they interpret these agents as guided by their mental states. Hearing children of this age have continuously, from birth, benefitted from an environment replete with conversational experiences.

Our conclusion is that a number of studies indicate that already among infants, implicit mind reading can be present without explicit mind reading skills. This fits nicely with another branch of research on ToM and the empirical data showing considerable variability in the age when verbally elicited or explicit mind reading emerges (Heyes & Frith, 2014). However, the more precise relation

between the two types of mind reading, i.e. if they rely on two different systems in a neurocognitive sense, or if it is one system with different developmental preconditions, or if implicit mind reading reflects a general neurocognitive mechanism with only explicit mind reading relying on a specific neurocognitive mechanism, remains unsettled (Heyes & Frith, 2014).

The relationship between implicit and explicit mentalising has been discussed in the literature in the context of other atypical developmental conditions. Adults with high-functioning Autism Spectrum Disorder (ASD) can be proficient at explicit response tasks, but lack the ability to cope with implicit tasks (Senju, Southgate, White, & Frith, 2009). Consequently, implicit non-verbal belief attribution does not seem to be a necessary precursor for the later developing explicit understanding of other minds (Senju et al., 2009; Frith & Frith, 2008). Therefore we have empirical evidence that infants during the latter half of the first year implicitly interpret events including agents in terms of mental states and at this age they do not pass traditional explicit ToM tasks, perhaps because these rely on verbal language skills. The findings of Senju et al., (2009) clearly show that coping with verbally loaded tasks is crucially facilitated by typical verbal skills, which should be no surprise. In this sense, implicit and explicit mentalizing are decoupled, but in an atypical way among the persons with ASD. At the same time, the results from ASD show how effective and compelling language is as a tool for reasoning, and for learning to reason about other minds, despite a “reluctant” social mind.

From our point of view, implicit ToM in the sense of Heyes and Frith (2014) is compatible with social cognition being open to an influence of environmental experience in conversational settings. We suggest that deaf parents foster implicit mind reading skills in interaction with their children in ways that hearing parents of deaf children do much less. The same should be expected for explicit ToM, where more verbal instruction to deaf children is needed than could be provided by hearing parents. Studies of deaf children shed new light on the conditions of the emerging

implicit and non-verbal belief attribution skills by suggesting that these skills are fostered and learnt through conversational input from caregivers during the first two years of life (Meristo et al., 2012; Morgan, Meristo, Mann, Hjelmquist, Surian, & Siegal, 2014). We reiterate from Meristo, Hjelmquist and Morgan (2012) that the preferred explanation of the delayed ToM among deaf children of hearing parents is: "...the very reduced early experience of conversation and its role as a vehicle for mind-coordination." (p. 58). We now turn to a discussion of what this early experience of conversation may entail.

Environmental enablers of ToM: Early interaction

Infants during their first year of life have already been involved in countless interactions with their parents. Language in these contexts is a prominent vehicle for gaining the attention of the infant, for monitoring and commenting on the infant's actions and for guiding the attention of the infant to outer and inner experiences (Meins et al., 2006; Meins, Fernyhough, Arnott, Leekam, & de Rosnay, 2013). In studies of hearing children by Meins and her colleagues, parents' references to mental states of the infant at 6 months of age were predictive of ToM at four years of age. A methodological issue is of course the common genetic affordances of children and parents. Strictly speaking, the common genetic variation might explain the correlation between parental talk and children's ToM, with little environmental influence. On the other hand, the rich experience of talk, and mental state talk in particular, might explain the presence of the very early non-verbal belief attribution. Presently, the empirical evidence strongly favours the latter alternative. Hughes, Jaffe, Happé, Taylor, Caspi, and Moffitt (2005) in a longitudinal study showed that individual differences in explicit ToM were explained mainly by environmental factors. This finding is concordant also with the accumulating evidence for considerable cultural variation in explicit-response ToM development (Vinden, 2001; Mayer, & Träuble, 2015).

Testifying to the importance of very early communicative experiences, there is evidence of the perceptual attraction to characteristics of sign language during the first year of life, though only among hearing children (Krentz & Corina, 2008). This study showed that hearing 6-month-old infants, the age at which Meins, Fernyhough, Johnson, and Lidstone (2006) studied parents' references to infant's mental states, were more sensitive to sign language information compared to complex pantomimes, similar to hearing infants' sensitivity to speech stimuli compared to complex acoustic stimuli. This speaks strongly in favour of deaf children of deaf parents processing sign language in the same perceptual and categorical way. Though there is no known direct link between the perceptual level of language and ToM, the findings by Krentz and Corina (2008) underline the importance of early access to conversational experience, whether spoken or signed, for stabilizing the building blocks of linguistic communication. Especially since it was also found that hearing 10-month-olds did not show any specific sensitivity to sign language information (Krentz & Corina, 2008) paralleling the loss of sensitivity to spoken linguistic contrasts in the same age group. It seems very likely that deaf children need sign language experiences from conversational contexts, in the same way that hearing children need spoken conversational experience to benefit from the informational potential inherent in linguistic communication (Kuhl, Tsao, & Liu, 2003).

Deaf children also offer a natural variation in terms of access to adult linguistic communication since deaf children born to hearing parents, about 90% of all deaf children, from the very beginning will not be enculturated into, and via, a common language. Until the point later in development when cochlear implants and intensive speech and language therapy begin to provide deaf children with functional spoken language skills they will not be immersed in accessible linguistic communication directed at them, notwithstanding that in several societies, as soon as deafness is discovered, parents are offered classes in a sign language. Signing with your baby is currently a very fashionable past-time for hearing parents with hearing infants, however

paradoxically, the increasing use of cochlear implants at early ages acts against deaf babies parents' interest in learning sign language. Irrespective of these considerations, during their first year, deaf children generally have very restricted access to a common mother tongue. However this is not the case for all deaf children. As documented, deaf children of deaf parents have age appropriate explicit ToM development and we know a lot about how early interaction in deaf families enables this.

Interaction environments in deaf and hearing parents of deaf children– what they do differently

Early studies of the interaction style of hearing mothers of deaf children compared to hearing mothers of hearing children described the former group as demonstrating a more directive style that resulted in less participation and initiation from the children. Consequently the children were less able to interpret their mothers' intentions (Lederberg & Mobley, 1990; Meadow-Orlans & Steinberg, 1993; Jamieson, 1995; Spencer, Bodner-Johnson, & Gutfreund, 1992; Wedell-Monnig & Lumley, 1980). Early research also refers to mothers' anxiety and feelings of incompetence in how to interact with a deaf child and this has been suggested as possible causes for interruptions in maternal responsiveness (Meadow-Orlans & Spencer, 1996). At the time parents are getting used to a new child the parent of a deaf infant is dealing with the stress and anxiety that can accompany a diagnosis of hearing impairment, making important decisions about amplification or implantation and often having to learn a new language at a time when language input is key (Koester & Meadow-Orlans, 1990). It is the case that early communication between a hearing parent and a deaf child is more challenging. Hearing parents are accustomed to communication via hearing and need time to adapt to the visual/tactile communication mode more appropriate for their deaf infant.

In contrast, deaf mothers of deaf children are reported in several studies to be more responsive to their children's changes in attention marked by small shifts in eye gaze. Hearing

mothers were more likely to miss these subtle signals or misinterpret them as inattention from the deaf child (Swisher, 1992). For the deaf mother, their child making eye-contact is interpreted as a request and looking away is a new topic initiation or an opportunity for their child to scan their environment before returning their gaze (Kyle, Woll & Ackerman, 1989; Loots et al., 2005; Gale & Schick, 2009). Spencer et al. (1992) reported that deaf mothers were much more likely to wait for their child to look back at them before responding than hearing mothers of deaf children (70% of time compared to only 16% of time by hearing mothers).

Several studies of deaf children of hearing parents have reported delays in establishing and using joint attention with their parents. In contrast when deaf children are immersed in an environment with sufficient visual communication with deaf parents, they develop joint attention skills at the same age and follow the same stages as hearing children (Harris, Clibbens, Chasin & Tibbitts, 1989; Tasker, Nowakowski & Schmidt, 2010; Lieberman et al., 2014). Meadow-Orlans and Spencer (1996) and Spencer (2000) reported that deaf parents/deaf child dyads spend just as much time in coordinated joint attention as hearing parents/hearing child pairs at 18 months. Deaf/hearing dyads spend a reduced total amount of time in joint attention at this age (Spencer & Waxman, 1995; Spencer, 2000; Gale & Schick, 2009).

Linked to the idea that early conversations play a role in the development of ToM skills is work on the importance of the input to young children from their caregivers containing certain mental state words and conversation styles. Taumoepeau and Ruffman (2006) showed that maternal mental state talk to hearing 15-month-olds correlated with later mental state language and emotion understanding at 24 months age. Furthermore mothers' reference to others' thoughts and knowledge at 24 months was the strongest predictor of children's mental state language at 33 months. Furthermore, differences in the quantity of time spent in joint attention and the quality of that interaction have been found. Morgan et al. (2014) carried out an analysis of conversational

experiences in two languages, English and Swedish, of deaf and hearing children aged 17–35 months with hearing parents.

The majority of the children tested in Morgan et al. (2014) knew spoken and signed language although language levels varied greatly between children. In the English sample, all deaf children had hearing parents who had minimal familiarity with British Sign Language (BSL). The children's language scores were assessed using the BSL and English MacArthur Bates CDI (Herman et al., 2010). Language scores in BSL ranged from 20 to 481 signs in comprehension and from 8 to 372 signs in production. Participants' English scores ranged from 4 to 393 words in comprehension and from 3 to 316 words in production. This massive individual variation was also reported for similar age children in Woll (2013). The procedure was the same for the English and Swedish sample. Morgan et al. (2014) asked parents to describe pictures that elicit mental and emotional state language to their children following the Taumoepeau and Ruffman (2006) methodology. The input to the deaf children from their hearing caregivers differed greatly in terms of mental state labels compared with hearing mother's talking to their hearing same age children. Parents of hearing children referred to cognitions (i.e., using words like 'think', 'know' or 'remember') significantly more often than did those of deaf children. There were no differences between groups in references to desires or emotions. For turn taking we found that the parent-hearing child dyads produced significantly more connected turns than did the parent-deaf child dyads. Connected turns were defined as all utterances semantically related to the other interlocutor's previous turn. Parents with a deaf child thus have a difficulty maintaining a conversation and are less likely to relate to the infants' immediately previous turn. Generally speaking, the results hold for both samples in two different cultures, and are compatible with the hypothesis that the lack of a common language, for directing attention and sharing experiences, have consequences for the quality of dialogues and development of mentalizing.

An interesting finding came from an analysis of a subgroup of the parents with deaf children who had sets of twins (one deaf and one hearing). Three sets of such parents talked very differently to their two children depending on their hearing status of each child. When they described pictures to hearing off-spring they used appropriate levels of mental state language (as compared with data reported in Taumoepeau & Ruffman, 2006) but they drastically reduced this input when describing pictures to their deaf children, instead using descriptions of colours, sizes and labelling (Morgan, unpublished data). This suggests that conversations are more parent-led when a deaf child takes part. Morgan et al. (2014) also examined the child vocabulary data as a variable in a correlation analysis and found no consistent patterns. Thus language itself as measured by the vocabulary size was not predicting how rich in mental state language these deaf children's interaction was with their parents. There are other things in language especially pragmatics that facilitate how interaction develops in deaf children. This difference between good vocabulary but poor pragmatics was also reported recently in an Italian study of children with CI at 24 months (Rinaldi, Baruffaldi, Burdo, & Caselli, 2013). In summary, deaf children of hearing parents show a consistently delayed development of ToM compared to hearing children and deaf children of deaf parents. However, deaf children of hearing parents follow the same progression from simple to more complex mental state understanding as do hearing children but this progression is considerably delayed (Peterson, Wellman, & Slaughter, 2012). This protracted development is in line with a degraded conversational and linguistic input.

Suggestions from the research for future intervention practices for families with deaf children

The findings from Morgan et al. (2014) have consequences for how we think about early language intervention with young deaf children and their hearing caregivers. For example results emphasize that the quality of the environment is an enabler of social cognitive skills but that this enabler need not be a massive part of the interaction. In the parent-hearing child dyads only 2-5% of

the interactions concerned references to cognitive and mental states yet this will be sufficient to enable age-appropriate ToM development. This point highlights how important early intervention in nursery schools and other settings are for deaf children but that training does not have to be a large amount of adaptation. While the implementation of early communication training package is complex we would recommend from a review of the evidence on ToM development in deaf children that interventions should be based on what is known about the interactive styles of deaf parents with deaf children (see Spencer, et al., 1992). Based on the available evidence for ToM in deaf children with hearing parents, our advice to parents would be to focus on developing communication strategies that work for a deaf child based on visual and tactile cues and learn to use a sign language from as early as possible. Such an approach is behind the creation of the UK's National Deaf Children's Society 'Family Sign Language Curriculum' (www.familysignlanguage.org.uk). Of course this stance does not mean that speech input should not be used with young deaf children. Clearly a deaf child should be exposed to the richest input possible in terms of spoken language but this should definitely not preclude natural gesture and exposure to a signed language from as fluent adult user as possible. These early communicative practices in an accessible language can of course change over time, with the expectation that many deaf children of hearing parents will go on to develop spoken language skills to their full potential (see Perez, Valsamede & Morgan, 2015). We would not recommend approaches which either force deaf children to avoid visual communication strategies (including gestures, signs and lip-reading) nor which advise parents to 'wait and see' if their deaf children develop spoken language before deciding to sign. The evidence suggests that any delays in establishing and taking part in communication or access to social interaction via an accessible language code have consequences for theory of mind that can be both problematic and long-lasting.

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