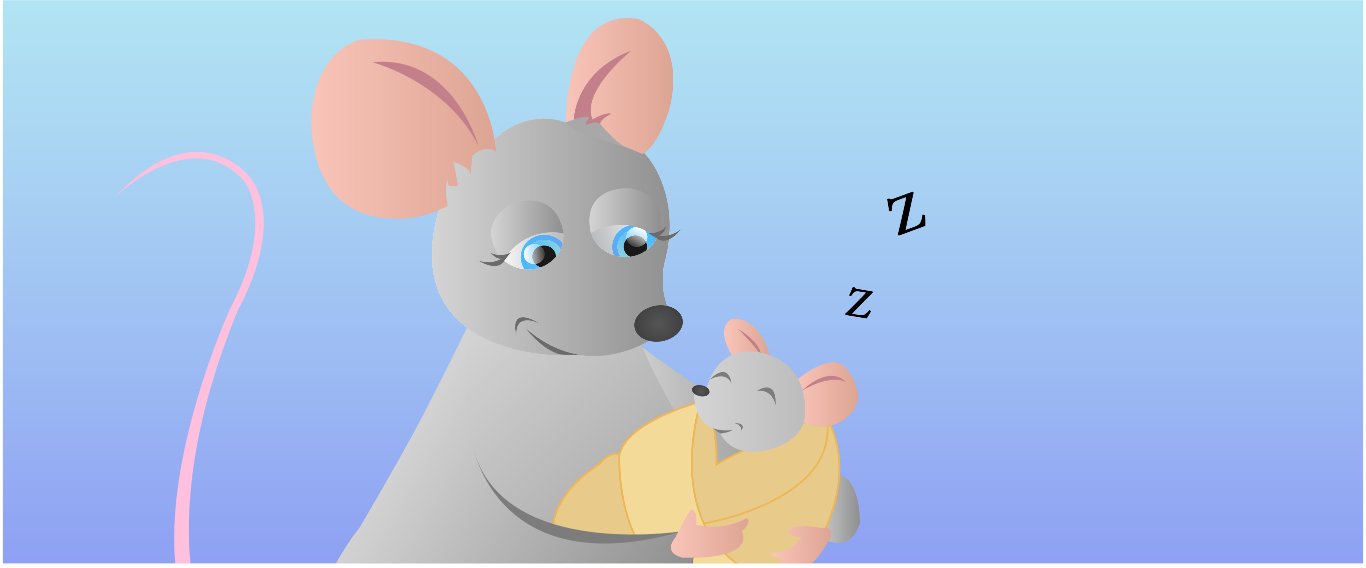
frontiers FOR YOUNG MINDS

NEUROSCIENCE
Published: 19 December 2016
doi:10.3389/frym.2016.00028



HOW CAN I MAKE MY YOUNGER SIBLING STOP CRYING?

Gianluca Esposito[1,2], Keegan B. Coppola[1] and Anna Truzzi[1]*

[1]Department of Psychology and Cognitive Science, University of Trento, Rovereto, Italy, [2]Division of Psychology, School of Humanities and Social Sciences, Nanyang Technological University, Singapore, Singapore

REVIEWED BY:


ANDREW
12 YEARS OLD


DAVID
12 YEARS OLD

When a baby will not stop crying, it can be frustrating. One well-known trick parents use is holding the child and walking around for a while. We are just now finding out why this trick works. It has to do with what happens in two different parts of the brain: the parasympathetic nervous system (PNS) and the cerebellum. The PNS is the brain's relaxation command center. When babies are carried, the PNS relaxes their bodies (by dropping the heart rate), which gradually calms them down and stops their crying. Also, carrying triggers the cerebellum, which controls movement and makes the babies physically adjust, for example, by bending their legs to the person carrying them. Understanding how the brain works will teach us how to better soothe babies. In turn, the people taking care of the babies will be more relaxed, which will improve health, happiness, and parent–child relationships.

BABY CRY: ANNOYING SOUND OR IMPORTANT COMMUNICATION?

Have you ever been stuck in the same room with a crying baby? If you have, chances are you know how difficult it can be to make the baby stop crying.

Or at least you know how difficult it can be for *you* to make him stop. Babies are soothed by their mothers more easily than anyone else. The baby might keep crying even when *you* give him his favorite toy, but he will calm down when his mother does the same. Do not worry, it is nothing personal—it is just the way babies' brains are wired! Because babies are so dependent on their parents, human beings grow close to their families very early in life. For example, imagine a puppy playing with her mom. Because the mom protects the puppy from potential danger, the puppy can grow up to start her own family. Once the puppy grows up and becomes a mother, this dog then protects the new babies until *they* grow up to make even more puppies. By protecting the youngest members of the family, animals guarantee the continued existence of their species. For this reason, mother–child relationships in many species are crucial to a baby's healthy development: their bond keeps the species alive. After all, who wants to live in a world without puppies?

One of the ways parents protect their children is by carrying them. Think back to that crying baby. How does his mom make him stop? She knows that babies only cry when they need something, so she tries to figure out what the baby wants. As mom scrambles to find the problem, she picks the baby up. The crying stops almost immediately. As parents have known for years, babies calm down when they are carried by their mothers [1]. However, it was not until recently that we learned why this happens.

WHY DOES CARRYING A CRYING BABY CALM THEM DOWN?

When babies are picked up, there are natural reactions in their bodies that help them calm down. Generally, babies will relax into their mothers' arms, making them easier to hold. When babies are picked up by their moms, their heart rates drop—a sign of relaxation. Any time a person becomes panicked, the heart rate speeds up. A crying baby has a high heart rate because he wants his mom. But when mom picks up the baby, these signs of panic decrease. Researchers noticed that babies being carried have lower heart rates than before they were picked up, which means that they are calmer than they were before. In other words, when a mom picks up her baby, the child cries less, moves less, and relaxes more. Of course, this will work for your little sister or brother, but it does not just happen in humans. This pattern has been studied in other animals too, and it is called the **transport response (TR)**. Healthy young animals relax when they are being carried. This is a normal TR.

TRANSPORT RESPONSE (TR)

When a baby is carried, he/she shows a specific set of responses, which calm him/her down (fewer movements and cry, slower heart rate) and which is called Transport Response.

EXPERIMENT WITH HUMAN BABIES

To find the mechanisms in the brain that make babies stop crying, experimenters tested a group of healthy babies and their mothers. Children were monitored in three different stages: in the crib, mom holding the baby, and mom carrying the baby. Babies left in a crib will usually start crying to protest being separated from their mothers. When the babies started to cry, researchers asked the mothers to pick up their babies. These mothers sat in a chair and held their babies for 30 s (holding condition, Figure 1A). Then they were asked to walk around, still holding the babies (carrying condition, Figure 1A). This lasted another 30 s. In this final stage, the babies relaxed into the embrace and stopped crying. These children reacted to their moms as soon as their mothers picked them up and started to walk around. All of them relaxed into their mothers' arms, slowed their heart rates, and stopped crying (Figure 1B). A representation of these changes is shown in Figure 1B. In the upper part of the graph, the vertical lines represent when the baby moves; in the middle of the graph, the horizontal bars represent when the baby cry; and in the lower part, the up-and-down continuous line represents the distance between two heart beats [**Inter-Beat-Interval (IBI)**]. The slower the heart, the higher the interval between two heart beats. Furthermore, the blue lines in the plot represent babies' reactions to holding, while the red parts represent babies' reaction to carrying. During holding, (blue) babies move and cry a lot and the interval between two heart beats is low; therefore, the heart rate goes fast. On the contrary, during carrying, (red) babies move less and do not cry and the interval between two heart beats is longer, meaning the heart rate goes slow. Carrying was the most effective soothing method. Leaving the babies

INTER-BEAT-INTERVAL (IBI)

The heart is a muscle that periodically contracts. Each contraction is called a "beat." The Inter-Beat-Interval is the time, which passes between two beats.

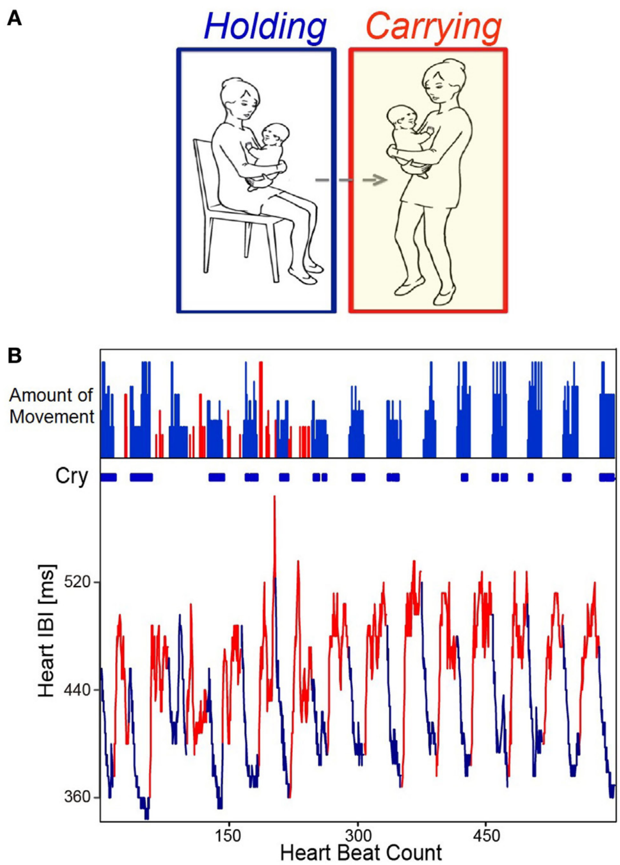


FIGURE 1

FIGURE 1

A. In our experiment, a mother "holding" her baby sits still, while "carrying" always means that mom is walking around with the baby in her arms. In all of our figures, blue will mean "holding" and red will mean "carrying." **B.** The graphs show the response of a 6-month-old baby to his mother carrying him. In the upper part of the graph, the vertical lines represent when the baby moves; in the middle of the graph, the horizontal bars represent when the baby cry; and in the lower part, the up-and-down continuous line represents the distance between two heart beats [Inter-Beat-Interval (IBI)]. The slower the heart, the higher the interval between two heart beats. Furthermore, following the same code described in **A.**, the blue lines in the plot represent babies' reactions to holding, while the red parts represent babies' reaction to carrying. During holding, (blue) babies move and cry a lot and the interval between two heart beats is low; therefore, the heart rate goes fast. On the contrary, during the carrying, (red) babies move less and do not cry and the interval between two heart beats is longer, meaning the heart rate goes slow (figure extracted from Esposito et al. [2]).

in the crib (crib condition) had no results, and holding was less effective than carrying. Indeed, during holding, it took much longer for the babies to relax and stop crying compared to carrying.

DOES CARRYING WORK ONLY FOR HUMANS?

In another test, researchers did similar experiments with mice instead of people [2]. These scientists placed baby mice in a cup, a few inches away from their mother. The babies began to cry about being separated from their moms, who came to rescue them immediately. When the moms picked up their babies to take them out of the cup, researchers watched the pups' physical reaction. They found that mice react similar to humans, since the baby mice usually stopped moving when they were being carried. When babies stop moving, this makes them easier to transport, which helps the mother.

HOW DOES THE TR WORK?

Because mice walk on all fours, they cannot hold babies in their arms the way humans do. Instead, the mother mouse uses her mouth to grasp a bit of skin at the back of the mouse pup's neck (Figure 2). Researchers were able to recreate this grip by pinching this same spot [3–6]. This way, the researchers had more control over the experiment. In the first mouse experiment described earlier, the researchers could not record all aspects of the pup's reaction, like heart rate. They also had to wait for the mother to come rescue her pups. In this new, controlled experiment, they were able to monitor the animals more closely. The researchers carried the pups by the skin on the back of the neck and watched their reactions. The pups acted a lot like they did when they were carried by their mother. Whether carried by an experimenter or their mother, the mouse pups dramatically relaxed during transport. As we also saw in humans, their heart rates fell quickly and they stopped crying.

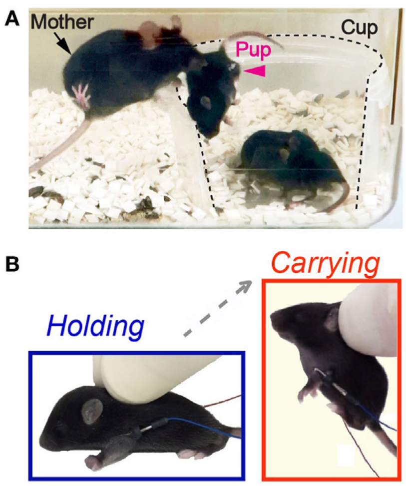


FIGURE 2

FIGURE 2

A. A mother mouse carries her pups out of the cups researchers placed them in for the experiment. This shows the way she transports her pups, as well as the way the pup holds its body when the mother picks it up. The pup holds itself in a small, tight posture, which helps the mother carry it, as it is easiest to move around a small, still pup. **B.** An experimenter uses his fingers to mimic the way the mother carries the pup, both during holding (blue) and carrying (red) (figure extracted from Esposito et al. [7]).

Because the mouse pups and the human babies reacted similarly, researchers began to use mice to better understand people.

Surprised that a researcher and a mouse mother had similar effects on the mouse pups, scientists began to wonder how the brain controls the TR. They knew for certain that the mouse pups relaxed when carried by a mother or a researcher. When either of these things happened, the pups felt the grip of whoever was carrying them and could sense their distance from the ground. This awareness controlled their TR. To understand how the TR is triggered, researchers gathered a new group of mice. These animals had a mutation, which means that they had a slight change in their DNA to make them different than normal mice. The DNA that was different in these mice was responsible for the development of the **cerebellum**. The cerebellum is the part of the brain that controls movement, in both mice and humans. When this group of mutant mice was tested, they did not react to being carried. Instead, these pups continued to squirm. All of the normal mice had frozen in place when lifted off the ground. But the mutant mice did not react like the others (Figure 3). Those who were squirming clearly showed the effects of their mutation.

CEREBELLUM

The cerebellum is responsible for movement coordination. We can jump or write because the muscles involved are activated in a coordinated way, and the cerebellum is responsible for this coordination.

This was another clue that the TR depends largely on the health of an animal or person, and this clue can help scientists to understand some disorders that affect the way an animal interacts with others. Because the mutant mice kept moving under the same conditions that caused the normal mice to become still, researchers believed that the lack of reaction to being carried was the result of cerebellum dysfunction. If a mouse moves when it is not supposed to, this movement comes from the cerebellum. Scientists think that similar signals from the cerebellum might control whether human babies stop crying when carried, too.

Finally, to study the change in heart rate that occurred during the experiment, researchers watched the part of the brain that controls the heart. This is called the **autonomic nervous system (ANS)**. If you want an easy way to remember the ANS, think of the word automatic. The two words, autonomic and

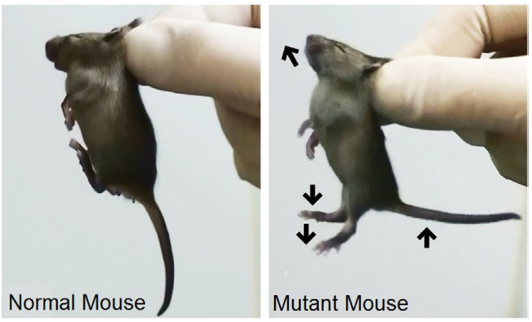


FIGURE 3

FIGURE 3

In both columns of the figure, researchers pinch a mouse pup at the back of the neck to recreate the way a mother carries her pup. The pup's response to the grip tells scientists about the pup's developmental state. The mouse in the first column is normal and relaxes into the grip of the researcher. The second column shows a mutant mice with changes in the DNA causing defects in the cerebellum, which is the brain area important for movement. These cerebellum defects cause changes in the pup' posture, as compared with normal mouse, when the pup is picked up by the researcher. The mutant mice are limp and stretched out, while the normal mice are in a small, tight posture. The arrows in the figure highlight the body parts that show abnormal response to carrying (figure extracted from Esposito et al. [2]).

automatic, sound very similar, because they mean the same thing! The ANS is responsible for all the things that happen in your body that you do not have to think about. Your body reacts to some things without you having to control it. Even though you do not think about your heart rate, or remind yourself to breathe, these things happen automatically. These functions are all controlled by the ANS. The ANS has two parts. They are called the sympathetic and parasympathetic branches. The **sympathetic nervous system (SNS)** controls "fight or flight" or panic reactions. When we are very scared, our bodies get ready to run or to defend themselves, which all happens because of the SNS. The **parasympathetic nervous system (PNS)** calms people down when they are no longer in danger. When a baby cries about being separated from his mother, the panic system is at work, meaning the SNS is active. However, when the mother picks the baby up, the baby's PNS calms him down by decreasing his heart rate. A lower heart rate means that the baby is calmer, so as his body returns to normal, and the baby feels secure and safe.

AUTONOMIC NERVOUS SYSTEM (ANS)

There are some vital functions, such as breathing, which are continuously done without the need for us to think about them. These functions are regulated by the autonomic nervous system.

SYMPATHETIC NERVOUS SYSTEM (SNS)

The sympathetic nervous system is the part of the autonomic nervous system, which controls the bodily reactions when we are anxious.

PARASYMPATHETIC NERVOUS SYSTEM (PNS)

The parasympathetic nervous system is the part of the autonomic nervous system that controls the bodily reactions when we are calm and relaxed.

In the experiment with mice, researchers injected two different kinds of drugs that blocked one of the two branches of the ANS. The first drug blocked the SNS. After the injection, there was no change in the heart rate response to being carried, carrying still slowed down the heart. However, when the same test was done after blocking the PNS, the heart rate no longer slowed down in response to being carried. This proved that the PNS is responsible for the baby's TR.

The science behind this discovery can improve people's lives. One way that this research will make a difference in the world is by teaching parents how to soothe their babies. When a baby did not stop crying, parents sometimes get very frustrated. For this reason, unstoppable crying is a leading cause of child abuse. The safer and easier it is to relax a baby, the less likely it is that innocent babies will be hurt by frustrated parents.

WHY UNDERSTANDING YOUNGER SIBLINGS' CRY IS IMPORTANT?

In this study, we learned babies stop crying when they are carried by their mothers. Researchers found that carrying calms babies, no matter what kind of babies they studied. From this research, we now know that animals physically relax when they are held by a walking mother. What is more, researchers discovered the mechanisms behind this calming response. With the knowledge that the parasympathetic branch of the ANS and the cerebellum control the TR, we now understand what happens in a baby's brain when the baby is carried by his caregiver. These behaviors, both maternal behaviors and the following babies' relaxation, help to keep our species alive. Furthermore, this study may help psychologists who are doctors trying to help people live better if the brain does not function completely well. The better doctors understand the healthy mind, the better they can diagnose brain problems in children who have them. Knowing about the normal response that happens when moms carry their babies, we can use the response to maternal carrying as an early test to show signs of certain disorders, like autism [8]. Since some children do not physically respond to being carried, psychologists have begun to explore these irregular interactions between parents and children to see if they predict future brain disorders. For example, a child who is developing normally relaxes into his mother's embrace when she carries him. But some parents report feeling "as if (they) were holding a stone or a sack of flour, not a baby," when their child is crying [5]. These were the parents of children who were not physically adjusted to fit parental carrying. If a baby does not react with the TR when carried, the baby himself/herself seems to be heavier because it is difficult to carry him/her.

Interactions with parents are crucial to every child's development. By teaching parents and children how to interact better with each other, scientists can improve communication between family members. Also, *everyone* can help this process by learning and sharing information like this. As authors, we chose to explain this discovery to a young audience because of how important it is to the future generations. The more we know about health and the brain, the better we understand ourselves. When parents know what controls the actions of a baby, they learn how to connect with that baby. At the same time, as scientists learn more about the brain, they can train parents on how to better interact with their children and to aid in healthy development.

ORIGINAL ARTICLE REFERENCE

Esposito, G., Yoshida, S., Ohnishi, R., Tsuneoka, Y., Rostagno, M. D. C., Yokota, S., et al. 2013. Infant calming responses during maternal carrying in humans and mice. *Curr. Biol.* 23(9):739–45. doi:10.1016/j.cub.2013.03.041.

REFERENCES

1. Hunziker, U. A., and Barr, R. G. 1986. Increased carrying reduces infant crying: a randomized controlled trial. *Pediatrics* 77:641–8.
2. Esposito, G., Yoshida, S., Venuti, P., and Kuroda, K. O. 2012. Three lessons from Philip Teitelbaum and their application to studies of motor development in humans and mice. *Behav. Brain Res.* 231(2):366–70. doi:10.1016/j.bbr.2011.10.008
3. Brewster, J., and Leon, M. 1980. Facilitation of maternal transport by Norway rat pups. *J. Comp. Physiol. Psychol.* 94:80–8. doi:10.1037/h0077645
4. Wilson, C., Nungaray, K., Garza, M., Raska, J., Kercher, M., and Lutterschmidt, W. I. 2008. Sit down and stay here! Transport response elicitation modulates subsequent activity in rat pups. *Behav. Processes* 77:131–4. doi:10.1016/j.beproc.2007.06.007
5. Esposito, G., Yoshida, S., Ohnishi, R., Tsuneoka, Y., Rostagno, M. D. C., Yokota, S., et al. 2013. Infant calming responses during maternal carrying in humans and mice. *Curr. Biol.* 23(9):739–45. doi:10.1016/j.cub.2013.03.041

6. Yoshida, S., Esposito, G., Ohnishi, R., Tsuneoka, Y., Okabe, S., Kikusui, T., et al. 2013. Transport response is a filial-specific behavioral response to maternal carrying in C57BL/6 mice. *Front. Zool.* 10(1):50. doi:10.1186/1742-9994-10-50
7. Esposito, G., Setoh, P., Yoshida, S., and Kuroda, K. O. 2015. The calming effect of maternal carrying in different mammalian species. *Front. Psychol.* 6:445. doi:10.3389/fpsyg.2015.00445
8. Kanner, L. 1943. Autistic disturbances of affective contact. *Nerv. Child* 2:217–50.

SUBMITTED: 11 July 2016; **ACCEPTED:** 01 December 2016;
PUBLISHED ONLINE: 19 December 2016.

EDITED BY: Nadine Gaab, Harvard Medical School, USA

CITATION: Esposito G, Coppola KB and Truzzi A (2016) How Can I Make My Younger Sibling Stop Crying? Front. Young Minds 4:28. doi:10.3389/frym.2016.00028

DISCLAIMER: The authors of this article would like to remind their readers that this discovery does not permit you to carry your siblings without a parents consent. Stay true to your rules at home and tell your parents about what you learned. Above all, be careful with younger siblings. As we just learned, their brains are pretty complicated, so it is important to treat them gently.

CONFLICT OF INTEREST STATEMENT: 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.

REVIEWED BY

ANDREW, 12 YEARS OLD

My name is Andrew, and I am 12 years old. I live in Seward, Nebraska, and go to Seward Middle School. I like playing sports, singing, and playing in band. I play percussion, because I love to make rhythms (and hit things too!). I have two brothers and one sister, and we like to play basketball together outside. I also like to go outside and play football with my friends.

DAVID, 12 YEARS OLD

Hi, my name is David, and I am 12 years old. I enjoy playing sports like basketball, football, and baseball. When I am not outside playing, I can usually be found watching TV, playing video games, or reading. My favorite author is Rick Riordan who writes books about Greek mythology. I have three brothers and a dog, and we all enjoy playing together! One of my favorite things to do with my family is to go to our cabin to boat and tube on the lake.

AUTHORS

GIANLUCA ESPOSITO

I am a developmental and Clinical Neuroscientist and I investigate child psychopathology. I am currently studying with several different techniques as to why and how infants' brain sometimes develops atypically in order to improve children's and parents' well-being. Furthermore, my studies focus on several mammalian species to understand how the interaction between parents and infants evolved, understanding from where and when they emerged. *gianluca.esposito@unitn.it and gianluca.esposito@ntu.edu.sg

KEEGAN B. COPPOLA

I am an American high school student completing a psychology summer internship. I have been working as Research Assistant at the University of Trento Affiliative Behavior and Physiology laboratory where I have worked on assessing central and peripheral brain activity using ECG and EEG. I have applied these methods in a project regarding mother–infant relationships, developmental disorders, and attachment patterns in early infanthood. This has fueled my passion for learning new things and enriched my understanding of psychology in action.

ANNA TRUZZI

I am attending the PhD program in Psychology and Cognitive Science. My research aims to understand how social interactions with parents shape infants development. Currently, I am involved in a joint project, which aims to investigate in non-human primates how good or bad parental behaviors affect infants responses to stress.