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REVIEW ARTICLE

MOTOR REACTIONS OF INFANTS IN RESPONSE TO OPTICAL FLOW – LITERATURE REVIEW

REAKCJA RUCHOWA NIEMOWLĄT W ODPOWIEDZI NA PRZEPŁYW OPTYCZNY – PRZEGLĄD LITERATURY

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ABSTRACT

Introduction

Eyesight is crucial for each child to achieve the stages of gross and fine motor development. One of the essential processes during movement is the effect of optical flow on the organ of vision and its influence on the performance of the movement. The phenomenon of optical flow is ubiquitous in everyday activities, and it is still not fully understood how it triggers a reaction.

Aim

The article is a presentation and summary of the research methodology of various research teams studying the influence of the optical flow on motor reactions in infants.

Material and methods

Review of publications searched using keywords (optical flow, motor reaction, reflexes, newborn, infant) in databases such as PubMed and ScienceDirect. The methods and conditions presented by various authors are summarized in one table.

Results and conclusions

Optical flow studies and the influence on motor reactions differ significantly in methodology and study groups, making it impossible to compare the results between all found publications. Most cited studies have shown that optical flow can induce or intensify a motor response in infants.

Keywords: newborn, optical flow.

STRESZCZENIE

Wstęp

Wzrok jest kluczowy w osiąganiu przez dziecko etapów rozwoju motoryki dużej oraz małej. Jednym z ważnych procesów podczas przemieszczania się jest działanie przepływu optycznego na narząd wzroku oraz jego wpływ na wykonanie ruchu. Zjawisko przepływu optycznego jest wszechobecne w codziennych czynnościach i ciągle nie jest w pełni zrozumiałe to w jaki sposób wywołuję reakcję.

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Cel
Przedstawienie i podsumowanie metodyki badań różnych zespołów badawczych w zakresie przepływu optycznego na reakcje ruchowe u niemowląt.

Materiał i metody
Przegląd publikacji wyszukiwanych z użyciem słów kluczowych (przepływ optyczny, reakcja ruchowa, odruchy, noworodek, niemowlę) w bazach takich jak PubMed i ScienceDirect. Wyniki wyszukiwania przedstawiono w postaci zbiorczej tabeli w celu usystematyzowania informacji oraz wyszczególnienia stosowanej metody.

Wyniki i wnioski
Badania przepływu optycznego i jego wpływ na reakcje ruchowe znacząco różnią się metodyką oraz grupami badanymi, co uniemożliwia porównane wyników między wszystkimi znalezionymi publikacjami. W większości cytowanych prac wykazano, że zastosowanie przepływu optycznego może wywoływać lub nasilać reakcję ruchową u niemowląt.

Słowa kluczowe: niemowlę, przepływ optyczny, reakcja ruchowa.

Introduction
Eyesight is one of the key senses that help infants to achieve their goal of the movement. Knowing how a person sees when he/she moves is the subject of research in many areas. One of the issues concerning visual perception correlated with the perception of the kinematics of the body is optical flow. Although the visual flow is ubiquitous in our daily activities, there is no clear opinion about the motor reaction to this visual stimulus and how the eye responds naturally to this phenomenon.

The phenomenon of optical flow can be understood as the perception of the movement of visual objects. Such a situation can be triggered when the observer is moving or is standing still, and other objects are moving. The moving images form a complex pattern of optical flow on the retina. This formula contains information about the amplitude and direction of the linear and rotational components of the natural motion that created the flow. Thanks to this phenomenon, a person can measure the distance from an object and avoid an obstacle while walking, running or driving (Gibson 1950,Lappe *et al.* 1999, Vaina *et al.* 2014). If the observer is not moving, but the objects around him are moving, the illusion of movement may occur. This sensation is described as a "vector" and is associated with the perception of certain moving objects' speed and direction of movement. As the observer moves forward, the optical flow expands or radiates outward; when the observer moves backward, it radiates inward or contracts.

The focus of flow expansion (FOE) is the point of convergence or radiation that often indicates the direction of the course (Hiu Mei Chow *et al.* 2021). Keeping the eyes in line with the moving FOE may be a strategy to stabilize the eyesight at the time of movement and facilitate body control during locomotion (Mathis *et al.* 2020).

The phenomenon of optical flow in infants was already studied in the 70s of the last century, but to this day, the phenomenon has not been fully understood. There is a broad spectrum of research into optical flow in infants. It is worth saying what questions the researchers asked: 1. whether optical flow may affect motor reactions in infants; 2. does independence of movement so experiencing one's own movement, significantly affect the perception of optical flow; 3. what is the sensitivity of infants to the optical flow stimulus.

Aim

The article aims to present the research methods used to study the motor reactions of an infant during visual impact in the field of optical flow and critically analyse the usefulness of the diagnostic methods used.

Material and methods

The author has reviewed the literature using the following keywords: optical flow, motor reactions, infants, newborns, walking. The set time criterion covered the period from 1950 to 2021 in PubMed, SciencDirect scientific databases. Subsequently, ten publications were selected, presenting studies on the motor responses of infants to the optical flow response. The author excluded all articles which did not deal with the movement of infants.

Results

The selected publications differed in the age of the studied group and methodology, which made a direct comparison of the results difficult (Table 1). Even more so, it turns out that the knowledge on this subject is not fully known.

An important common feature of all studies is the standard features of the pattern that was presented to infants. First of all, the picture had to be large and contrasting, and the most frequently used colours were black figures on a white background. In Marianne Barbu-Roth's research, the most frequently used pattern was a black and white chessboard.

Five studies analyzed the influence of the optical flow direction. The research shows that moving towards the observer, so imitating the forward movement of the observer triggers more significant reactions. In one study, infants retracted their heads or blinked their eyes to the flow response (Nanez *et al.* 1994).

Two articles compared motor responses depending on the achievement of certain stages in developing a child's great motor responses. The results showed that children who did not crawl made more movements in the air than when in contact with the ground. Infants who could move achieved a similar number of steps in conditions above the ground and in contact with it (David *et al.* 2014). It seems that the acquisition of the ability to move on a solid surface strengthens the child's nervous system's ability to adapt its own movement to the observed movement of objects.

Table 1. Summary results.

Art.	**Study group; flow velocity**	**Research tools Method**
Berchental B. I., *et al.* (1989)	Only on the basis of an abstract	Infants' sensitivity to optical flow to control sitting and standing was tested using a "moving room" in which all walls moved together or only the side or front walls moved.
Nanez J., *et al.* (1994)	Only on the basis of an abstract	The textured region of light expanded and contracted on the dark screen for back projection. The texture elements (15 black dots) expanded and contracted radially from the center of the screen as if they were on a single surface (single depth display) or independent (multi-depth display) transducers and digitally sampled by a 12-bit A / D converter at a frequency 60 Hz. File integration of left and right signals reflected head movements along the anterior-posterior sagittal X axis An infrared video camera was also used to record the condition of the infant. All the experimental procedure was computer controlled.
Joene F., *et al.* (2000)	25 newborns. The physical speeds were 0.01; 0.02; 0.04; 0.06; 0.08; 0.10 and 0.12 m/s, which correspond to the perceived angular speeds of 2.5; 5.0; 10.0; 15.0; 20.0; 25.0 and 30.0 degrees per second	Babies placed in a car seat that allowed them to remain seated (tilt at an angle of 25°). Two patterns are shown. Additionally, seven experimental speeds were used.

Table 1. (cont.) Summary results.

Art.	**Study group; flow velocity**	**Research tools Method**
Leiuene L., *et al.* (2006)	91 full-term infants aged 9 months were divided into 3 groups: 1. Crawl Experienced 2. Beginners in crawling 3. Non-crawling;	A room with movable walls covered with dark blue and white fabric. The children were placed in a bicycle seat. Their behavior is recorded by a digital camera, recording the face and body of the infant throughout the experiment. Each infant underwent 12 trials, exposed to two optical flow conditions: global optical flow (G) and global optical flow minus terrestrial optical flow (GT), and the infants were checked for crawling after the trials.
Barbu-Roth M. *et al.* (2009)	48 newborns, age: 3 days Image speed 0.17m/s	Displaying the image on the underside of the table has two flow patterns: chessboard and windmill. The therapist held the child above the table at an angle of 35–40° to the table surface. The therapist's grip was not supposed to block the movements of the lower and upper limbs.
Moerchen V. A., *et al.* (2012)	12 infants aged 2–5 months and 12 infants aged 7–10 months	This study investigated treadmill walking in two groups of premotor infants in response to terrestrial visual flow. Optical flow was supplied by the running belt to shift the flow directionally with the infants' step forward
Barbu-Roth, *et al.* (2014)	22 3-day-old babies. Flow speed 0.17 m/s	The infants were tested under four conditions: (with a one-minute break between conditions): 1. Baby held in the air above a moving pattern – direction to the baby 2. Kept in the air over a pattern moving away from the baby 3. In the air held above a static pattern 4. Tactile stepping forward across the table surface with the table surface illuminated by diffused white light to minimize optics flow while moving. Kinematics was studied using optical markers.
Barbu-Roth M., *et al.* (2015)	22 infants aged 2 months Flow speed 17m/s	A table on which the image from the projector was reflected. The visual stimulus consisted of a black and white chessboard The infants were tested under four conditions: (with a 1-minute break between conditions): 1. An infant held in the air above a moving chessboard pattern – towards the child 2. Kept in the air over a checkerboard pattern moving away from the baby 3. In the air held above the static pattern of a chessboard 4. Tactile walking forward on the table surface with the table surface illuminated by diffused white light to minimize optics flow during movement.
Anderson J. D., *et al.* (2016)	33 infants, but the data included 18 infants aged 6 to 13 months, divided into crawling and crawling children; The flow velocity is 0.27 m/s	Optical flow patterns were projected onto a white screen on the floor. The cameras recorded the movements of the babies. The children were in a dark room, each child underwent 6 trials lasting 1 minute. Three optical flow conditions (approaching, receding and static) were created in two child positions (contact with the ground and above the ground).
Forma V., *et al.*(2018)	26 newborns aged 3 days; Flow speed 0.12 m/s	Used: a transparent pediatric mattress filled with water; cameras; optical flow projector. The study examined the crawl characteristics of newborns placed on their stomachs on a water-filled transparent pediatric mattress, and investigated whether exposure to terrestrial optical flows that define forward and backward displacement would affect leg and arm movements. 3 attempts: I the chessboard moves towards the baby, II from an infant III static formula.

One study looked at the effects of speed on infant behavior. The study group consisted of 25 newborns aged three days. Newborns were placed in a special seat, set at an angle of 25 degrees. Monitors were placed on either side of the baby's head. Airbags with pressure measurement were used to measure the pressure of the head. They were placed

at the level of the temporal and occipital bones of the skull. The study aimed to present children the optical flow at seven different speeds and test the pressure on the airbags caused by the movement of the observer's head. The results showed that the intensity of the observed reaction depended on the flow velocity (Jouen *et al.* 2000).

Articles on examining newborns and assessing the motor reaction to optical flow are an essential aspects. The study mentioned above included 48 newborns aged three days. The prepared research stand consisted of a table, two cameras, and a projector with a computer. The pattern emitted from the projector was a black and white chessboard moving towards or away from the child. The second pattern was a black fan on a white background that moved clockwise. Two experimentalists participated in the study. The first of them held the newborn over the table, one hand supporting the chest below the armpits so as not to obstruct the movement of the arms, while the other hand supported the pelvis. The second researcher dealt with technical issues related to the operation of the computer and projector and controlled the behaviour of the newborn. The children underwent four trials lasting 1 minute. The intervals between them also lasted 1 minute, and the order of the examination was randomized, taking into account fatigue and decreased attention of newborns. Children were examined in two conditions: 1. when the child was not in contact with the ground (held above the table in the air), and; 2. the child has been in contact with the ground (child's feet rested on the table). In setting 1, the child was shown a chessboard moving towards the child, a static chessboard pattern and a windmill moving clockwise. In setting 2, a white background was presented to a child. The results indicate that the children also moved their lower limbs in the air, stimulated by optical flow, which may point to a residual coupling between optical flow and locomotion present from birth. The flow direction also influenced the quantity: the movement towards the baby stimulated a stronger reaction. The smallest number of repetitions of the moving limbs appeared during the projection of a black spinning windmill or a static image.

It is known that the walking reflex occurs during tactile stimulation, although it may not be necessary from the above studies to initiate the reflex. Additionally, it is worth mentioning that arm movement was observed during the research, which may not have been visible in other studies because the researchers prevented the child from gripping it (Barbu Roth *et al.* 2009).

In another study, Marianne Barbu-Roth examined older children. This group consisted of 22 children aged two months. The fundamental element of the test stand was a table on which the image from the projector was reflected. The visual stimulus consisted of a black and white chessboard. The infants were tested under four conditions with one-minute gap between trials:

1. An infant held in the air above a moving chessboard pattern – direction towards the child;
2. Kept in the air over a chessboard pattern moving away from the child;
3. Held in the air over a static chessboard pattern;
4. In contact with the table surface.

It was observed that infants made more limb movements in the air than in contact with the ground. Children made more movements of the limbs in contact with the ground and more when the direction of flow was towards the child. Important in these studies is the joint conclusion that tactile and visual stimulation may induce treading in the neonatal period (Barbu Roth *et al.* 2015).

The latest study from 2018 involved a kinematic assessment of the movement of the lower and upper limbs of newborns at the age of 3 days. A special stand was created for the study, consisting of a transparent mattress filled with water, under which a visual stimulus in the form of optical flow was displayed. The newborns were placed on

their stomachs on a water mattress and were subjected to three trials. In the first one, the optical flow towards the baby was displayed. In the second, the direction away, in the final, the chessboard pattern did not move. In all conditions, the children tried to bend and straighten the legs and arms. A difference was observed in the larger number of movements during the emitted optical flow. It is also worth mentioning that children performed movements more frequently with the right upper limb and the left lower limb. The explanation of this phenomenon is not fully understood, although it is suspected that at such young age, lateralization may be revealed. However, the author of the publication is more convinced by the theory that most babies in the mother's womb assume a position where the head is rotated to the right. For this reason, the more significant activity of the right upper limb may result (Forma *et al.* 2018).

The flow velocity was also different. Most often, it was set at 17 m/s. It is worth mentioning that one study focused on how velocity influenced response. The authors observed that the infants reacted by tilting the head back, the size of which was linearly related to the speed of optical flow.

Discussion

In the 70–90s, research focused on determining the influence of optical flow on the occurrence of a child's reaction, in particular attention. During this period, two scientific paths appeared based on the information already gained. The first is the influence of optical flow on neuropsychological aspects (focus, concentration). Neuropsychologists primarily focused on the age factor, i.e. at what stage the child responds most to the optical flow stimulus. Two studies have shown that the reaction has started at the age of two months. The most remarkable response occurred in 8-month-old infants, with 10-month-old infants having a weaker response, which the researchers explained by shorter attention span due to exploration of the environment.

The second field of research concerned the relationship between neurology and ophthalmology. The optical flow assessment in these studies was related to assessing the reaction speed and the perception of visual stimuli. As research in these pathways unfolded, researchers focused on children or the elderly. Studies in infants investigated whether optical flow triggers a kinematic response in infants without linking them to pathological conditions / developmental abnormalities.

The research carried out at the beginning of the 21st century focused on assessing the influence of optical flow on the child's locomotion. Determining whether the response obtained depends on the child's motor performance. Therefore, using optical flow and its reactions to assess the existing neurological disorders in newborns/infants seems interesting. The child may have a limited response to optical flow, or the response will not increase as it does in healthy peers. Optical flow can then be used as a neurodiagnostic tool for children.

Many publications reflect the traditional assumption that a newborn's eyesight is immature to connect with the outside world compared to the connections provided by tactile-auditory perception. Therefore, it is worth presenting studies that show that vision can also initiate the walking reflex in newborns. The research pioneer is Marianne Barbu-Roth. She researched various age groups and experimental conditions. She tried to answer whether the visual stimulus can also cause crawling in the neonatal period. In two studies by Marianne Barbu-Roth, newborns moved their lower and upper limbs during the presentation of optical flow.

The most common goal of the research was to examine the number of movements made during the presentation of optical flow and the static formula.

Another aspect that has been addressed and still unclear is the effect of optical flow velocity. In one of the studies that examined this dependence, it was observed that this aspect is essential, and children reacted more

strongly to the higher speed of the flowing image.

The research mainly lacked information on the distance of the presented optical flow from the observer (child). The disadvantages of the conducted study were primarily the small numbers of children.

Optical flow research is still an open topic, providing a field for scientists, therapists and paediatricians as a possible diagnostic tool.

Conclusions

Based on the conducted literature research, it can be concluded that optical flow as a stimulus may trigger or intensify the motor reaction in infants.

Optical flow is still an object of research with unstructured research methodology, which may modify the obtained effect. The researchers did not identify the unified impact of the angle of holding the child, other stimuli (e.g. a gust of air), or the way of holding the child.

Objectification of the conducted research should be characterized by video analysis along with mapping of kinematic chains, allowing the assessment of the movement itself (amplitude/range) and the frequency and occurrence of specific movement patterns.

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