Neonatal pain scales study: A Kendall analysis between eye-tracking and literature facial features*

Fernanda G. Tamanaka[1], Lucas P. Carlini[1], Tatiany M. Heideirich[1], Rita C. X. Balda[2], Marina C. M. Barros[2], Ruth Guinsburg[2], Carlos E. Thomaz[1]

[1]Departamento de Engenharia Elétrica
Centro Universitário FEI (FEI) – São Bernardo do Campo – SP – Brazil

[2]Departamento de Pediatria
Universidade Federal de São Paulo (UNIFESP) – São Paulo, SP – Brazil

fernandagoyo@hotmail.com,ruth.guinsburg@gmail.com, cet@fei.edu.br

Abstract. *Newborns (NBs) feel pain and the more premature they are, the more immature are their pain attenuation system. Facial expression recognition is a non-invasive method to identify and evaluate their feelings, since it provides relevant information about pain and the NB's emotional state, allowing discrimination with non-painful stimuli. In this context, this study proposes to use Kendall's correlation coefficient to quantitatively compare the relevance between the facial areas reported in literature to evaluate the NB's pain with the facial areas observed by health professionals and lay people, through eye-tracking, when performing the visual pain assessment task on the NBs' facial images. The results showed that the visual perception of adults does not agree with the facial areas proposed by the literature for pain analysis. In addition, the results suggest that health professionals present a distinct perception when compared to the perception presented by non-health professionals. We believe that such results might help to improve pain assessment carried out clinically.*

1. Introduction

Newborns (NBs) feel pain and the more premature they are, the more immature are their pain attenuation system. It means that, in response to repeated painful stimuli, the premature NB can present an increase of pain sensation [Vinall et al. 2012, Gimenez 2018]. Consequently, the prolonged exposure to pain during the first days of birth, may result in emotional, behavioural, and lifelong changes in those NBs [Anand et al. 1999, Vinall et al. 2012]. Pain can bring many comorbidities to the NB hospitalised at a Neonatal Intensive Care Unit (NICU), thus pain identification methods (e.g. cry, motor activity and facial expression) have been implemented and applied in the clinical practice [Grunau et al. 1998, Guinsburg 1999, Caetano et al. 2013, Cong et al. 2013, Maxwell et al. 2019, Bueno et al. 2020]. Firstly, even though crying is the NB's main communication, it could be triggered by non-painful stimuli, such as hunger and/or other discomfort. Thus, it must be evaluated along with physiological and behavioural characteristics. The same criteria must be applied for motor activity since it may occur through painful and/or unpleasant stimuli, and therefore, it is possible to misjudge pain with discomfort by their reaction. On the other hand, facial expression is a good resource to

*Supported by FEI, CNPq (371658/2020-9), FAPESP (2018/13076-9) and CAPES.

identify pain in NBs, since it is a non-invasive method that provides relevant information about pain and the NB's emotional state, allowing discrimination between non-painful stimuli [Heiderich 2013].

In [Carlini et al. 2020], the authors presented novel results on human visual perception regarding neonatal pain assessment through facial expression. Their results showed that there is no statistical difference on the number and time fixation at human visual perception between all groups of volunteers when holistically comparing facial regions described by the Neonatal Facial Pain Scale Coding System (NFCS) [Grunau and Craig 1987], whether they were health professionals or not. Consequently, these findings suggest that all sample groups looked statistically at the same areas of interest (AOIs) and it is reasonable to assume that visual analysis was equal for all groups studied. More recently, [Carlini et al. 2021] showed qualitative results suggesting that adults visual perception agree with the same specific facial features proposed by the literature, like the regions of the eyes, mouth and forehead; showing a representative number and time of fixations.

In this present study, we extended these experimental results to perform a quantitative and comparative analysis between the importance of NBs facial characteristics proposed by the literature and the volunteers' visual perception by using Kendall's correlation coefficient [Kendall 1938]. We believe that these findings might provide new insights to help the health professional to evaluate and classify the NB's pain, as well as support the clinical decision.

2. Materials and Methods

In this section, we describe the methodology applied to analyse facial features related to human visual perception and the computational framework proposed initially in [Carlini et al. 2019, Carlini et al. 2020]. In the end of this section, we explain how to identify the areas of interest and its importance to the results.

2.1. Literature review

We have searched on Google Scholar, Semantic Scholar, Research Gate, Web of Science, Europe PMC and publishers of books and journals, such as Elsevier, PubMed and Scielo, using the following keywords: neonatal pain scale, newborn pain scale, and neonatal facial scale, from April to December 2020, without considering the paper publication date. In total, 150 studies that included facial scales for neonatal pain assessment were found, but only 52 explained the origin and/or process of clinical validation of these scales. However, 39 scales described the pain phenomenon as a holistic facial feature defined mainly as grimace or composed of general facial expression changes. Consequently, 13 scales that didn't present this feature were analysed in this work: NFCS [Grunau and Craig 1987], Modified NFCS (M-NFCS) [Rushforth and Levene 1994], McGrath Facial Affective Scale (MCGRATH or FAS) [McGrath 1985], Nepean Neonatal Intensive Care Unit Pain Assessment Tool (NNICUPAT) [Marceau 2003], Modified infant pain scale (MIPS) [Buchholz et al. 1998], Partial MIPS (P-MIPS) [Buchholz et al. 1998], Premature Infant Pain Profile (PIPP) [Stevens et al. 1996], PIPP Revisited (PIPP-R) [Stevens et al. 2014], Evaluation Enfant Douleur (EVENDOL) [Fournier-Charrière et al. 2012], Liverpool Infant Distress Scale

(LIDS) [Horgan and Choonara 1996], Acute Pain Scale (APN) [Carbajal et al. 1997], Pain Assessment scale for Preterm Infants (PASPI) [Liaw et al. 2012] and Behavioral Indicators of Infant Pain (BIIP) [Holsti and Grunau 2007].

Table 1. Relationship between scales and facial features

Facial Features	Clinical Scales														
	NFCS	M-NFCS	MCGRATH	NNICUPAT	MIPS	P-MIPS	PIPP	PIPP-R	EVENDOL	APN	LIDS	PASPI	BIIP	Total	Percentage Total
Right Eye (REye)	1	1	1	1	1	1	1	1	1	1	1	1	1	13	14.29%
Left Eye (LEye)	1	1	1	1	1	1	1	1	1	1	1	1	1	13	14.29%
Region between Eyebrows (RBEb)	1	1	1	1	1	1	1	1	1	0	1	1	1	12	13.19%
Forehead	1	1	1	1	1	1	1	1	1	0	1	1	1	12	13.19%
Mouth	1	1	1	1	1	1	0	0	1	0	1	1	1	10	10.99%
Right Nasolabial Groove (RNG)	1	1	1	1	1	1	1	1	0	1	0	1	1	11	12.09%
Left Nasolabial Groove (LNG)	1	1	1	1	1	1	1	1	0	1	0	1	1	11	12.09%
Chin	1	0	1	0	1	1	0	0	0	0	1	0	0	5	5.49%
Right Eyebrow (REb)	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2.2%
Left Eyebrow (LEb)	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2.2%
Nose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
Right Cheek (RC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
Left Cheek (LC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
Other regions face (ORF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
Total	8	7	8	7	8	8	6	6	5	7	8	7	7	92	100.00%

According to the literature review there are 14 AOIs (Table 1), but firstly we considered the following 6 facial regions (Figure 1): 1) **Right and Left Eye (1R/1L)** (Eye squeeze; Frown; Eyes tense; Distressed look); 2) **Region between Eyebrows**; 3) **Forehead** (Furrowed forehead; Furrowed brow; Brow bulge); 4) **Mouth** (Open mouth; Tense mouth; Horizontal mouth stretch; Vertical mouth stretch; Lip purse; Open lips; Taut tongue; Tongue protrusion); 5) **Right and Left Nasolabial Groove (5R/5L)** (Nasolabial furrow); 6) **Chin** (Chin quiver). Additionally, we considered more AOIs that were not described by the literature: 7) **Right and Left Eyebrow (7R/7L)**; 8) **Nose**; 9) **Right and Left Cheek (9R/9L)** and 10) **Other regions face (ORF)** that the adult could observe, but was not described in any of the previous regions. However, it is important to understand that, since we consider Left (L) and Right (R) as distinct facial regions, we analysed (in total) 14 AOIs.

2.2. Computational framework

The proposed framework, described in more details in [Carlini et al. 2020], is a series of computational experiments carried out from March 15 through April 17 of 2019. In total, 143 volunteers of the São Paulo Hospital (university-affiliated hospital of the Federal University of São Paulo - Brazil); performed pain assessment on twenty (20) NBs frontal face images of ten (10) different neonates. Each pair of images consists of one image of the neonate at rest and another image after a painful procedure routinely and clinically performed (Figure 2), evaluating each one using a numerical scale ranging from 0 (no pain) to 10 (extreme pain). This image dataset was developed by health professionals and researchers [Heiderich 2013, Heiderich et al. 2015] and approved by the Ethics Committee for Research of the Federal University of São Paulo (1299/09, 3.116.151, 3.116.146 and 3.201.307).

The volunteers were divided into four groups of study:

- 44 physicians: 4 paediatricians and 40 neonatologists;
- 40 health professionals (HPs): 17 nursing assistants, 10 nurses, 5 physiotherapists and 8 speech therapists;
- 29 newborn's parents;
- 30 others (lay people: non-physicians, non-health professionals, and non parents of newborn).

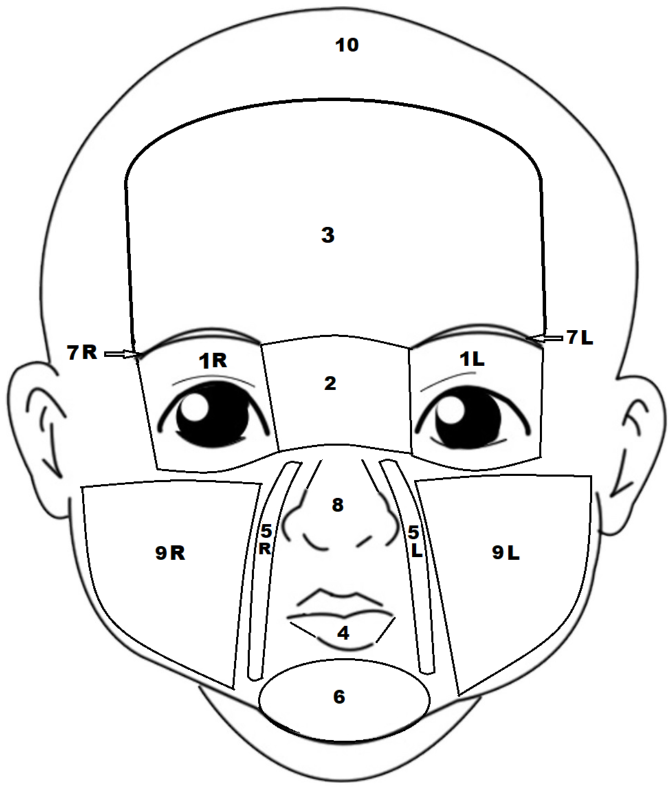

Figure 1. NB facial features.
*Author (The image was created from a hypothetical NBs face designed by [Heiderich 2013, Heiderich et al. 2015]).

The experimental procedure [Carlini et al. 2020], illustrated in Figure 3, is composed of the following 3 main steps: (1) an instruction screen is shown to the subject; (2) presentation of two evaluation trials, so that the subjects can learn and comprehend the experiment; and (3) the beginning of the experimental procedure itself. Each neonatal face image to be evaluated is non-centralised located on the screen and is shown randomly to the volunteer for seven seconds. Subsequently, the participant had three seconds to answer verbally the score (0 to 10) for the displayed image, as being 0 no pain face and 10 the extreme pain. The total time to perform the experiment was approximately 5 minutes for each volunteer. In each session of the procedure, information regarding the ocular evaluation strategy of each volunteer was recorded by the Tobii TX300 eye tracking equipment. Exclusion criteria was applied to volunteers with diagnoses of epilepsy (seizure) and/or severe ocular problems.

2.3. Eye-tracking acquisition and processing

Using Tobii Studio software, we have manually drawn each facial regions accordingly to table 1. Such features are known in the eye-tracking literature as Areas of Interest (AOIs) and an example is shown on Figure 4.

In order to compare the visual perception of distinct sample groups and its corresponding relationships, we evaluated Kendall's correlation coefficient [Kendall 1938]. This is a non-parametric hypothesis test for statistical dependence on populations that take on a ranked order. Since we want to identify the agreement of the most preferred AOIs

(a) No Pain.

(b) Pain.

Figure 2. Example of two images presented in the UNIFESP dataset.

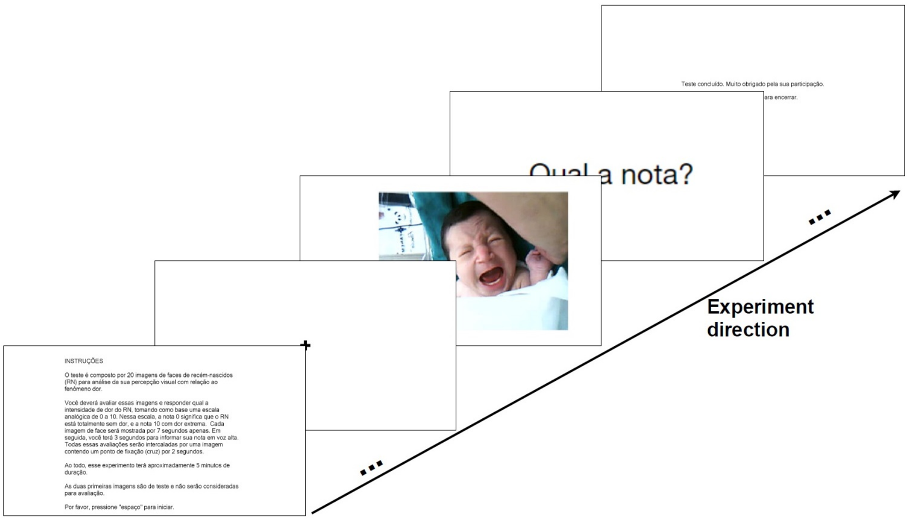

Figure 3. Eye-tracking study.

between distinct sample groups, Kendall's correlation provides the measurement of the agreement between them. Consequently, correlations commonly used like Spearman's and Pearson's correlation can't be considered.

We have calculated Kendall's correlation coefficient [Kendall 1938, Santiago 2016, Agresti 1984] using Python software with Pandas, Seaborn and Matplotlib libraries on three situations: 1) all images (ten images of pain and ten images without pain), 2) pain images only (ten images) and 3) without pain images only (ten images). This correlation indicates that values above or near to 0.7 show that groups are applying the same pattern when observing facial regions [Santiago 2016].

Prior to evaluating Kendall's correlation coefficient, we have normalised (for each sample group) the total time and fixation amount data for each AOI by the corresponding values of the entire face, as shown on Table 2.

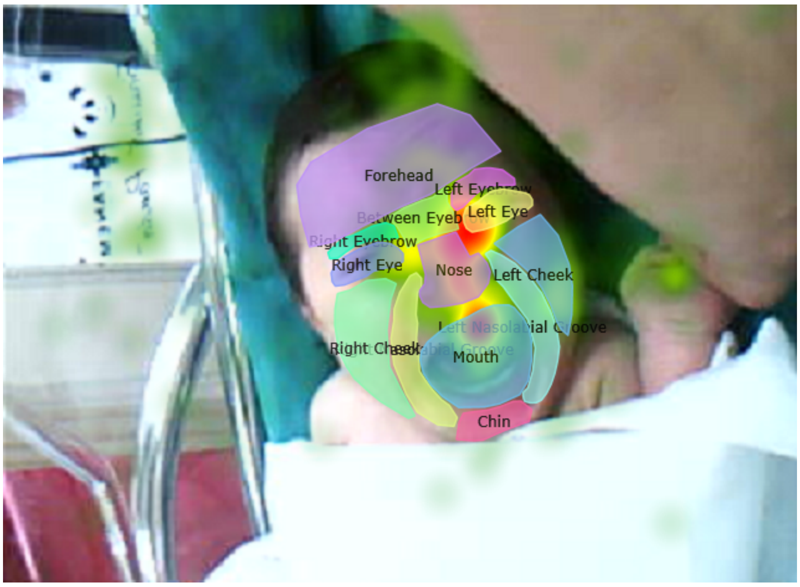

Figure 4. Example of visual perception on each AOI.

Table 2. Fixation and Duration amount percentage for each AOI.

AOIs	Literature	HPs		PHYSICIANS		OTHERS		PARENTS	
		FIX	TIME	FIX	TIME	FIX	TIME	FIX	TIME
REye	14.29	6.93	6.00	6.64	5.86	8.78	8.18	8.64	6.66
LEye	14.29	9.25	8.05	8.84	7.39	9.15	7.64	9.84	8.81
RBEb	13.19	7.22	9.8	6.28	7.68	8.16	9.32	6.94	6.99
Forehead	13.19	9.87	6.67	5.4	4.25	13.71	8.92	12.2	5.28
Mouth	10.99	14.81	14.06	16.42	15.97	11.50	8.72	14.37	13.97
RNG	12.09	3.44	3.26	3.11	2.57	2.98	2.96	3.66	2.65
LNG	12.09	3.61	3.01	4.99	5.16	3.52	3.61	2.95	2.95
Chin	5.49	2.71	1.45	2.66	1.8	1.53	0.31	1.41	1.09
REb	2.2	2.12	2.11	1.41	1.25	2.31	2.34	3.01	2.03
LEb	2.2	2.78	2.57	2.16	1.94	3.14	2.43	2.12	1.95
Nose	0	22.47	29.52	22.46	28.91	24.21	32.89	21.91	32.18
RC	0	1.48	0.82	1.21	0.63	1.61	0.94	1.9	1.16
LC	0	3.06	1.58	3.69	2.22	3.16	1.66	2.85	1.38
ORF	0	10.25	11.08	14.72	14.38	6.23	10.09	8.19	12.91

Caption: FIX(fixation); AOI (areas of interest); HPs (Other Health professionals); REye (Right Eye); LEye (Left Eye); RBEb (Region between Eyebrows); RNG (Right Nasolabial Groove); LNG (Left Nasolabial Groove); REb (Right Eyebrow); LEb (Left Eyebrow); RC (Right Cheek); LC (Left Cheek); ORF (Other regions face)

3. Experimental Results

The results shown on Table 3 describe the relationship between fixation amount and its duration for ”Face” and ”non-Face” image regions of each group of volunteers. Comparing the number of fixation of all sample groups, Physicians and HP’s looked more at the face of NBs, regardless of the scenario analysed. On the other hand, HP's and Parents showed the highest number of fixation at "Out of the Face" regions. Analysing the time of fixation, Physicians and HP's looked for a longer time than others sample groups at out of the face regions.

Table 3. Values of fixation and duration amount images (all, pain and without pain), in both cases: Face and out of Face.

Indicators	All images			
	Parents	Physicians	Others	HP
Face Fixation Total	5518	8934	5538	7783
Out of Face Fixation Total	4823	4239	3379	5238
Face Duration Total (seconds)	2808.91	4430.19	2862.59	3680.69
Out of Face Duration Total (seconds)	792.79	965.85	684.86	1138.59
Indicators	Pain			
	Parents	Physicians	Others	HP
Face Fixation Total	2811	4445	2745	3855
Out of Face Fixation Total	2290	2022	1723	2538
Face Duration Total (seconds)	1426.32	2179.90	1404.82	1839.20
Out of Face Duration Total (seconds)	365.43	448.64	345.93	559.16
Indicators	No Pain			
	Parents	Physicians	Others	HP
Face Fixation Total	2707	4489	2793	3928
Out of Face Fixation Total	2533	2217	1656	2700
Face Duration Total (seconds)	1382.59	2250.28	1457.77	1841.50
Out of Face Duration Total (seconds)	427.36	517.21	338.93	579.43

Table 4 shows that NBs facial features described by pain scales are not correlated with eye-tracking findings. In other words, AOIs found on literature pain scales do not have the same relevance as the visual perception of adults when assessing pain (e.g. nose, cheek and other regions of face).

Table 4. Kendall's correlation between sample groups and proposed AOIs by the literature.

Category of images	Fixation			
	Parents	Physicians	Others	HP
All	0.2912	0.3145	0.2912	0.2446
Pain	0.1980	0.1980	0.2446	0.2213
No Pain	0.2679	0.1980	0.2446	0.2446
Category of images	Time			
	Parents	Physicians	Others	HP
All	0.2912	0.2446	0.2446	0.2679
Pain	0.2213	0.1640	0.2213	0.2679
No Pain	0.2679	0.2213	0.3378	0.2446

Table 5. Kendall's correlation within sample groups when observing "no pain" images.

No pain images	Fixation			
	Parents	Physicians	Others	HP
Parents	1	0.5824	0.8022	0.7363
Physicians	0.5824	1	0.6484	0.8462
Others	0.8022	0.6484	1	0.7143
HP	0.7363	0.8462	0.7143	1
No pain images	Time			
	Parents	Physicians	Others	HP
Parents	1	0.8462	0.7363	0.8901
Physicians	0.8462	1	0.7582	0.8681
Others	0.7363	0.7582	1	0.8022
HP	0.8901	0.8681	0.8022	1

Table 6. Kendall's correlation within sample groups when observing "pain" images.

Pain images	Fixation			
	Parents	Physicians	Others	HP
Parents	1	0.7582	0.8681	0.8462
Physicians	0.7582	1	0.7582	0.9121
Others	0.8681	0.7582	1	0.8462
HP	0.8461	0.9121	0.8462	1
Pain images	Time			
	Parents	Physicians	Others	HP
Parents	1	0.7956	0.8681	0.8681
Physicians	0.7956	1	0.7514	0.8398
Others	0.8681	0.7514	1	0.8681
HP	0.8681	0.8398	0.8681	1

Table 7. Kendall's correlation within sample groups when observing all images.

All images	Fixation			
	Parents	Physicians	Others	HP
Parents	1	0.6923	0.8242	0.7802
Physicians	0.6923	1	0.7363	0.8681
Others	0.8242	0.7363	1	0.7802
HP	0.7802	0.8681	0.7802	1
All images	Time			
	Parents	Physicians	Others	HP
Parents	1	0.8462	0.8242	0.8901
Physicians	0.8462	1	0.7582	0.8681
Others	0.8242	0.7582	1	0.8462
HP	0.8901	0.8681	0.8462	1

When we have analysed eye-tracking Kendall's correlation coefficient of "no pain" images (Table 5), we observed that, in both scenarios (Fixation and Time), Physicians had the highest correlation with HP, but a lower Fixation correlation when we compared with remaining groups, especially with Parents Fixation. However, when we analysed "pain" images (Table 6), all groups had a higher correlation in both scenarios (Fixation and Time), especially for the fixation amount of the Physicians with HPs and the fixation of Parents with Others. Lastly, when we analysed all images (Table 7), all groups presented a high correlation in both scenarios (Fixation and Time), except the Fixation correlation between Parents and Physicians that was inferior to 0.7.

4. Conclusion

This paper shows human visual perception results on neonatal pain assessment of face images that might help to improve the understanding of relevant facial features to perform such assessment, either automatically or clinically.

When we compared the literature with the human visual perception, it is noteworthy that Kendall's correlation coefficient for all cases is low (<0.7), especially for experts (physicians and health professionals). These results suggest that facial features observed by adults when assessing pain don't agree with the ones described by the literature. Later, when comparing the agreement between distinct sample groups, we observed that physicians are more correlated with the health professionals groups, presenting a lower correlation with parents and others. It seems that physicians and health professionals have a distinct facial perception when assessing pain in newborns when comparing to non-health professionals (parents and others). These results are expected since physicians and health professionals have been trained to assess pain clinically.

As future works, we intend to develop a pain classification system based on the most relevant NBs facial characteristics observed by visual perception and the literature scales. We believe that such system might help to improve pain assessment carried out clinically.

References

Agresti, A. (1984). Analysis of ordinal categorical data. Technical report, J. Wiley.

Anand, K., Rovnaghi, C., Walden, M., and Churchill, J. (1999). Consciousness, behavior, and clinical impact of the definition of pain. In *Pain Forum*, volume 8, pages 64–73. Elsevier.

Buchholz, M., Karl, H. W., Pomietto, M., and Lynn, A. (1998). Pain scores in infants: a modified infant pain scale versus visual analogue. *Journal of pain and symptom management*, 15(2):117–124.

Bueno, M., Stevens, B., Barwick, M. A., Riahi, S., Li, S.-A., Lanese, A., Willan, A., Synnes, A., Estabrooks, C., Chambers, C., et al. (2020). A cluster randomized clinical trial to evaluate the effectiveness of the implementation of infant pain practice change (impac) resource to improve pain practices in hospitalized infants: a study protocol. *Trials*, 21(1):16.

Caetano, E., Lemos, N., Cordeiro, S., Pereira, F., Moreira, D., and Buchhorn, S. (2013). O recém-nascido com dor: atuação da equipe de enfermagem. *Escola Anna Nery*, 17(3):439–445.

Carbajal, R., Paupe, A., Hoenn, E., Lenclen, R., and Olivier-Martin, M. (1997). Apn: a behavioral acute pain rating scale for neonates. *Archives de pediatrie*, 7(4):623–628.

Carlini, L., Soares, J., Silva, G., Heideirich, T., Balda, R., Barros, M., Guinsburg, R., and Thomaz, C. (2020). A visual perception framework to analyse neonatal pain in face images. pages 233–243.

Carlini, L. P., Heideirich, T. M., Balda, R. C., Barros, M. C., Guinsburg, R., and Thomaz, C. E. (2019). Visual perception of pain in neonatal face images. In *Anais do XV Workshop de Visão Computacional*, pages 37–42. SBC.

Carlini, L. P., Tamanaka, F. G., Soares, J. C., Silva, G. V., Heideirich, T. M., Balda, R. C., Barros, M. C., Guinsburg, R., and Thomaz, C. E. (2021). Neonatal pain scales and human visual perception: An exploratory analysis based on facial expression recognition and eye-tracking. In *Pattern Recognition. ICPR International Workshops and Challenges: Virtual Event, January 10–15, 2021, Proceedings, Part II*, pages 62–76. Springer International Publishing.

Cong, X., Delaney, C., and Vazquez, V. (2013). Neonatal nurses' perceptions of pain assessment and management in nicus: a national survey. *Advances in Neonatal Care*, 13(5):353–360.

Fournier-Charrière, E., Tourniaire, B., Carbajal, R., Cimerman, P., Lassauge, F., Ricard, C., Reiter, F., Turquin, P., Lombart, B., Letierce, A., et al. (2012). Evendol, a new behavioral pain scale for children ages 0 to 7 years in the emergency department: design and validation. *Pain*®, 153(8):1573–1582.

Gimenez, I. (2018). Dor em prematuros: concordância entre três escalas e descrição do conhecimento dos fisioterapeutas do município do rio de janeiro. Master's thesis, Universidade Federal do Rio de Janeiro.

Grunau, R. and Craig, K. (1987). Pain expression in neonates: facial action and cry. *Pain*, 28(3):395–410.

Grunau, R., Oberlander, T., Holsti, L., and Whitfield, M. (1998). Bedside application of the neonatal facial coding system in pain assessment of premature infants. *Pain*, 76(3):277–286.

Guinsburg, R. (1999). Avaliação e tratamento da dor no recém-nascido. *J Pediatr (Rio J)*, 75(3):149–60.

Heiderich, T. M. (2013). Desenvolvimento de software para identificar a expressão facial de dor do recém-nascido. Doutorado em ciências, Universidade Federal de São Paulo.

Heiderich, T. M., Leslie, A. T. F. S., and Guinsburg, R. (2015). Neonatal procedural pain can be assessed by computer software that has good sensitivity and specificity to detect facial movements. *Acta Paediatrica*, 104(2):e63–e69.

Holsti, L. and Grunau, R. (2007). Initial validation of the behavioral indicators of infant pain (biip). *Pain*, 132(3):264–272.

Horgan, M. and Choonara, I. (1996). Measuring pain in neonates: an objective score. *Paediatric nursing*, 8(10):24–27.

Kendall, M. (1938). A new measure of rank correlation. *Biometrika*, 30(1/2):81–93.

Liaw, J.-J., Yang, L. H., Chou, H.-L., Yin, T., Chao, S.-C., and yeh Lee, T. (2012). Psychometric analysis of a taiwan-version pain assessment scale for preterm infants. *Journal of clinical nursing*, 21 1-2:89–100.

Marceau, J. (2003). Pilot study of a pain assessment tool in the neonatal intensive care unit. *Journal of paediatrics and child health*, 39(8):598–601.

Maxwell, L., Fraga, M., and Malavolta, C. (2019). Assessment of pain in the newborn: An update. *Clinics in perinatology*, 46(4):693–707.

McGrath, P. (1985). Multidimensional pain assessment in children. *Advances in pain research and therapy*, pages 387–393.

Rushforth, J. A. and Levene, M. I. (1994). Behavioural response to pain in healthy neonates. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, 70(3):F174–F176.

Santiago, M. (2016). Métodos de estimação de fiabilidade e concordância entre avaliadores. *Departamento de Matemática, Universidade de Aveiro, Aveiro*.

Stevens, B., Gibbins, S., Yamada, J., Dionne, K., Lee, G., Johnston, C., and Taddio, A. (2014). The premature infant pain profile-revised (pipp-r): initial validation and feasibility. *The Clinical journal of pain*, 30(3):238–243.

Stevens, B., Johnston, C., Petryshen, P., and Taddio, A. (1996). Premature infant pain profile: development and initial validation. *The Clinical journal of pain*, 12(1):13–22.

Vinall, J., Miller, S., Chau, V., Brummelte, S., Synnes, A., and Grunau, R. (2012). Neonatal pain in relation to postnatal growth in infants born very preterm. *Pain*, 153(7):1374–1381.