Novel pulse oximetry sonification for monitoring preterm neonates on oxygen support

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Introduction: Premature neonates often require continuous oxygen support because their respiratory system is underdeveloped. Pulse oximetry is a standard form of medical equipment that provides information about a patient’s oxygen saturation (SpO2) and heart rate. An auditory “beep” tone plays in time with the heart rate, and the tone’s pitch reflects the percentage of haemoglobin that is oxygenated in the patient’s blood. Adult target saturation ranges are typically 96% to 100%, but the current recommended target saturation range for premature neonates is 90% to 95% SpO2 (Saugstad & Aune, 2014). For adults, therefore, an increasing pitch in the pulse oximetry tone is always desirable. For neonates, in contrast, an increasing pitch could mean either that SpO2 is returning to target range, or that it is rising above the target range. It is already difficult to keep premature neonates on oxygen support within recommended SpO2 levels (Claure & Bancalari, 2013; Janata & Edwards, 2013) but the ambiguity of the pulse oximeter sounds exacerbates the difficulty.

In this research we explored whether clinicians’ awareness of neonates’ SpO2 can be made more accurate by redesigning the auditory component of pulse oximeters for use with neonates (Hinckfuss, 2014; Hinckfuss, Sanderson, Liu, Browning, Loeb, & Liley, in press). This research has particular application in situations when a premature neonate is being transported between care locations, when visual information may be less available and clinicians may depend on auditory monitoring.

Our so-called Beacon pulse oximetry sonification uses a grace note, or “beacon”, which sounds immediately before every fourth tone when SpO2 is out of the normal range. The beacon informs the listener that SpO2 is out of the recommended range. In addition, because the beacon tone plays at the same pitch as the middle of the target range, it also informs the listener how much above or below the target range the neonate’s current SpO2 level has deviated. We predicted that participants listening to the Beacon sonification would more accurately identify the range into which SpO2 fell than when they listened to a Control sonification based on current industry standards. Our focus was on participants’ ability to discriminate broad SpO2 levels rather than their ability to make clinical interpretations.

Method: The experiment used a within-subjects design, with 56 participants experiencing both the Beacon mapping and the Control mapping in a counterbalanced order of presentation. Non-clinical participants listened to a series of short (20 second) pulse oximetry scenarios. At the end of each scenario they identified whether SpO2 was in the Very High, High, Normal, Low, or Very Low range, and whether SpO2 was Increasing, Steady, or Decreasing. The primary outcome was participants’ accuracy at identifying SpO2 range.

Results: Participants were significantly more accurate at identifying SpO2 range when they used the Beacon sonification (85% correct) than when they used the Control sonification (60%) (p < 0.001).

Discussion: Participants could identify the range in which the SpO2 fell much more accurately with the Beacon sonification than with the control sonification. This is a remarkable improvement given that participants had very little training. Further refinement of the Beacon design could lead to even greater accuracy. Overall, we hope to create an unambiguous pulse oximeter sonification that more accurately informs clinicians of the premature neonate’s SpO2 during transport.

Keywords: auditory displays, sonification, patient safety, pulse oximetry, neonatal transport

References
